Science, Society and Scientific Attitude

BANGALORE UNIVERSITY
BANGALORE

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**Let noble thoughts
come to us from every side**

TEN FUNDAMENTAL DUTIES

1. to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem ;

2. to cherish and follow the noble ideals which inspired our national struggle for freedom ;

3. to uphold and protect the sovereignty, unity and integrity of India ;

4. to defend the country and render national service when called upon to do so ;

5. to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities ; to renounce practices derogatory to the dignity of women ;

6. to value and preserve the rich heritage of our composite culture ;

7. to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures ;

8. to develop the scientific temper, humanism and the spirit of inquiry and reform ;

9. to safeguard public property and to abjure violence ;

10. to strive towards excellence in all spheres of individual and collective activity, so that the nation constantly rises to higher levels of endeavour and achievement.

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Published by
H. R. Dasegowda
Director, Prasaranga
Bangalore University, Jnana Bharathi, Bangalore 560 056

Printed at
Prasaranga, Bangalore University

To the Graduates . . .

The Bangalore University effected a number of meaningful changes in 1973 in conducting the annual convocation. The University decided that the graduates should be presented with a thought-provoking book published specially for the occasion. It is a matter of satisfaction that this useful practice has resulted in the publication of the fourth book in the series.

For the first time the University arranged seventeen lectures by men of eminence on several aspects of the theme, "Science, Society and Scientific Attitude." These lectures were generally largely attended. The University succeeded in creating an academic and intellectual atmosphere which is so essentially needed for its development. These seventeen articles have been compiled in the form of this book which is presented to you as a memento on this memorable occasion, the twelfth annual convocation. This will always remind you of the impact of science on several aspects of society and the need for the cultivation of a scientific temper.

I hope by reading this book you will come to know that education is a never-ending process stretching far beyond this event.

With best wishes for a purposeful and useful life.

H. Narasimhaiah

Vice-Chancellor

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Science and Education

Prof. Nurul Hasan
Minister for Education,
Government of India

The history of the growth and development of human civilisation, in fact the history of man himself, has almost entirely been the result of man's eternal search for progress and self-betterment. Throughout the centuries of his evolution from the primitive to the modern, man has always striven to improve his lot by attempting to resolve the contradictions which he sees in him and around him, by persevering in his search for knowledge of his environment and by understanding nature and her laws. He has not only attempted to establish a greater harmony between himself and nature but, on innumerable occasions, has sought to bend her to his will and command so that the hardships of his struggle for existence could be mitigated, hoping that life would become a source of joy and satisfaction. Due to these reasons the relationship between man and nature has also not remained static, but has evolved in various directions. Civilisations have had their ups and downs. Whatever the attitude or the result, the quest for knowledge as a means of controlling nature has been the core of man's conscious personality. The origin of science and technology and the position of importance gained by them in man's daily existence are phenomena which have sprung directly from his deep seated urge to investigate, to know and to control the forces surrounding him.

A distinguished scholar has observed that magic, religion and science have emerged from the same root, namely, the desire of man to deflect nature from the course it would have otherwise followed. Gradually, science completely outstripped magic and led to a reinterpretation of religion. Aspects of religion which ran counter to science such as superstition, obscurantism and the belief that supernatural forces interfered in human life came to be rejected by more and more people as the validity of science began to prove itself. Smallpox, for example, was no longer regarded as a curse from which cure is possible only by propitiating the Goddess; nor is the lunar eclipse to be regarded as an occasion to save the moon from evil forces by means of prayers or ceremonial ablutions. Contamination, it is now accepted, results from dirt, germs or viruses, and not from the shadow or touch of the low-born. Thus, the concept of religion is being reformulated as science grows and extends the frontiers of human knowledge.

How did this happen? The process began when science started increasingly to observe nature and discover its laws. The understanding of nature was characterised more and more by the study of data which were objectively verified. Science charted a course independent of intuition, subjective experience, or a priori dogma. As the efficacy of the scientific method became apparent, the concept of blind faith received a major setback.

The turning point came when, after a series of brilliant conclusions reached on the basis of scientific knowledge and objective analysis, man gained confidence in his powers of deduction and comprehension. What had begun as tentative groping, now became conclusions backed by deep study and reinforced by increasing observation. Man began to see the scientific process as a continuing one, which, if applied

correctly, could unravel the mysteries of the universe that had hitherto held him in awe.

With the passage of time other major developments took place. Science no longer concerned itself merely with the observation of nature, but began to interfere with nature in order to verify its observations. The experimental method with its accent on reproducibility, verifiability and control over the phenomena, enabled man to test the validity of the laws of nature which had been formulated, to discover new relationships and causal connections and employ the quantitative method in the understanding of nature.

From time immemorial man had been utilising devices and techniques to solve his problems. To begin with, these were based on accidental discoveries or empirical knowledge. Such knowledge, however, remains divorced from an understanding of why and how a certain technique works in the way it does. It was not initially possible to draw theoretical conclusions from the techniques or consciously apply theoretical knowledge for the purpose of refining old techniques or evolving new ones. There was thus, a complete separation between science and technology or their connection at best, was tenuous. Technology tended to remain a mystery confined to small groups of craftsmen often dying out, as the last practitioners of the art disappeared from the human scene. Since science could not be refurbished continuously with the experience gained from technology, its growth was stunted or slowed down. Similarly, technology without science could not reach the levels of achievement which it later did.

Technology has been principally concerned with production. The mode of production has therefore exercised a determining influence on society and it has not been possible

for social relationships to escape the limitations of the techniques of production. Equally, the pattern and organisation of society has affected the growth and development of science on the one hand and technology on the other. The relationships of society and its organisations include its social composition, its economic, political and administrative set-up, its ideas and ideals, its moral and ethical concepts and its spiritual and religious outlook. Many societies in the historical past provided intellectual roadblocks to the growth of science. One cannot forget, for example, the great astronomers of the sixteenth century being burnt at the stake by the Inquisition, or the mystics, notwithstanding their high moral and ethical standards, their compassion and concern for human beings, their tolerance and humanitarianism, who could not foist an intellectual climate in which scientific ideas would prosper.

It would thus be seen that science, technology and society cannot grow and develop in isolation from each other. While the pace of growth of each need not necessarily be the same, in the long run, the three cannot be placed in separate compartments. Society can hardly grow beyond a point without science and technology while science and technology cannot grow in a vacuum, divorced from social objectives or the moral compulsions evolved by society.

Our national leaders have placed certain guidelines before the nation. Our commitment to the concepts of socialism, secularism and democracy, our belief in the composite national heritage of India, the concept of progress ensuring egalitarianism, non-exploitation, providing equality of opportunity with no distinction of colour, sex or creed, are social values which have also been fully accepted as objectives of the policies of our Government. We realise that it is only by following this path that India can be built into a strong

united and progressive nation. It is also acknowledged that the forces of science and technology must be harnessed and adapted to fulfil the requirements of our domestic situation. We want for this purpose, not merely good scientists, engineers, doctors and technicians but Indians of a high calibre who will, with confidence, place the latest and most sophisticated technological know-how at the service of the masses of our people.

These are the national and social aspirations which we have placed before us and science and technology cannot be neutral or moral. It has become all the more vital for science to be imbued with a definite social purpose when the amazing growth in the power and scope of science and technology is kept in mind.

Today, science and technology have penetrated our social, political and economic system so deeply and with such drastic consequences for human survival, that they have become a critical factor in development and can be ignored only at our own peril. Scientific knowledge is increasing exponentially and doubles itself after every seven to ten years. It is only natural, therefore, that all responsible societies are acutely concerned with this growth of knowledge and its application. This concern has already revealed the extent to which scientific knowledge has revolutionised the world in the past two centuries. It has also opened up fresh vistas and avenues of social change particularly because scientific and technological progress has influenced the whole framework of ideas and possibilities within which the boundaries of our social and moral aspirations are determined. The pace of these changes may be so accelerated that they can be achieved not in centuries but in a matter of decades. There is, in short, at any given moment, a variety of possible courses before us.

Science and society are intertwined in more ways than one. The most significant achievement of science, for example, is the creation of wealth. In fact there is no period in the history of mankind in which so much wealth has been generated as is now being experienced in the industrialised world of today. Science and technology are an expensive proposition. They are not concerned merely with the pursuit of scientific research to solve specified problems. The various components of the innovative process, whether it be fundamental or applied research, require a major investment of resources. However, in spite of this, the dividends obtainable from successful innovations bring such tremendous financial, economic and industrial benefits that the essential socio-economic considerations for evaluating innovation tend to be frequently ignored. The short-term, transitory aims of selfish vested interest gains sway. Society is exposed to the critical dangers of consumerism and an excessive dependence on material goods. This, in turn, leads to a certain spiritual and cultural emptiness which, if unchecked, develops into a state of neurosis and a complete paralysis of the social conscience.

Then again, as a result of the wealth it generates, science has received a massive political patronage and the national governments all over the world have assumed the responsibility of supporting it. However, the wealth generated by science and technology has almost always remained concentrated in the hands of a select minority partly because of the scale of technology, and partly due to the deficiencies in the prevailing social order. In a free market society, sophisticated technology can be owned only by those who possess a large investment capacity and the help of hired scientific and technical expertise. This way, science has been used as an instrument of oppression, accentuating the gap between the rich and the poor.

Societies and nations have come to be categorised as advanced or backward. An island of unimaginable wealth and prosperity has been created amidst poverty and squalor. A whole range of mischievous theories and philosophies has sprung up to defend the present state of affairs when the resources of the earth are being monopolised by the wealthy-few and where disparities in incomes and standards of living are increasing due to the fact that the developing nations do not even control the resources which they themselves own. In our day, this grave injustice has led to the demand for a new economic and social order in which the benefits of man's achievements, in the field of science and technology or elsewhere, will be shared equally by all mankind.

Man is an integral part of nature. He is evolved from the environment around him through a process of behavioural responses. His development is linked with and limited by his environment by virtue of his dependence on the chemical, physical and biological processes. Recent researches have amply shown that human instinct and behavioural responses are acquired by the genes from environment itself. The environment thus becomes the determining factor in man's developmental growth. Since both man himself and the universe around him are imperfect entities, the process of human civilisation has consisted of efforts to supplement the natural environment on the one hand and to replace it by a man-made environment on the other. It is obvious that this has to be done cautiously because an untrammelled freedom to change and exploit the natural environment will expose mankind to grave dangers. It demands creativity of the highest order. Used with caution and insight, science can not only provide man with a deeper understanding between himself and nature, but also help him to transcend his physical limitations and realise his ambition of a better life.

It is obvious therefore that science and society must become parts of the same culture. A tendency has developed as a result of our colonial heritage, of treating science and technology as separate and distinct from social purposes and humanistic objectives. This tendency, which has received a stimulus from capitalism and imperialism, has caused incalculable harm. The issue has been confounded further by the fact that in rapidly changing scientific and technological situations, the system of human values does not often keep pace with development. Due to the rapid rate of turnover of scientific knowledge, society itself has to adjust to its economic and material base within shorter and shorter intervals of time. The result is often that one can see several variations of social values at any given moment in the development of a society. The state of flux becomes almost a permanent one and man himself tends to lose his moorings unless social objectives and purposes are constantly examined and redefined in the light of changing conditions.

These objectives can only be achieved if the system of education of a society or nation is made an effective channel for the communication of these ideas to the masses of the people, particularly the younger generation. The process of education is an attempt by mankind to understand man himself, his environment, his society so as to enable him to achieve social objectives and reach the heights of humanism.

A school or university cannot be an island in the sea of humanity. It has to be an integral part of the community in which it is situated. Education must expose the community to the scientific temper, to rational modes of thought, to creativity, to productivity. Education must be a process which helps our people to simultaneously fight against poverty, disease, illiteracy, ignorance and superstition. It must mould minds into a greater awareness of social responsi-

bilities. It must create a consciousness among the people that it is for them to find solutions to chronic problems, to usher in an intellectual and social revolution which is long overdue, and to use the resources at their disposal to bring about a visible improvement in the quality of life of the people within the shortest period of time. Perhaps the most powerful vehicle for social change and alleviation of age-old suffering, deprivation and disease, is the vehicle of science and technology.

The learning of science and technology in our schools and universities is necessary to develop new skills. It is also essential for fully comprehending the processes of society so that they can be changed in accordance with the highest code of morality, and the enrichment of the human personality. It is therefore essential that science should be used to promote the spirit of free inquiry, to abolish inequality between nation and nation, man and man, to test all assumptions in the crucible of scientific analysis.

There is equally a tendency on the part of some scientists and technologists, even of policy makers, to think that science and technology can grow without a close intermerging with education. Unless the whole society is attuned to science and technology, unless younger minds, by their questioning, continuously force the not-so-young scientists to re-examine their hypothesis, unless newer generations are trained to participate in the process of research and production and to challenge the fundamentals, the growth of science and technology might well get into a set groove.

When translated into concrete educational programmes, these basic concepts would imply that education must lead to the full development of the human personality, intellectually, physically, and morally, the adoption of cherished

social and human values and a firm commitment to these values. The educated Indian citizen must be a self-reliant personality imbued with the joy of living, rejecting dogma and superstition, fully involved in the productive processes of society and equipped with a knowledge of science and technology not only to solve the problems of the future and for the attainment of these great objectives, but also for the solution of the simple problems of everyday life. It must be remembered that many of the difficulties which our society has been facing for centuries have arisen because of an inadequate knowledge of science and our primitive technology. Let us now use the most sophisticated scientific knowledge to reduce the harshness of daily chores to which our people are exposed.

By the same token, it is essential that the teaching of science should receive the greatest possible emphasis in our school system. If the purpose of education is to create in man the capacity to discover himself and develop his potential in harmony with his natural and social environment, it stands to reason that man must develop within himself a fearless objectivity which will enable him to test his most cherished thoughts and beliefs on the anvil of scientific analysis. If we are to attain the goals of socialism, secularism and democracy and provide complete equality of opportunity, it is necessary that our economic and industrial system must have horizontal and vertical mobility to enable the unskilled worker to reach the senior-most levels of management and skill. It is thus essential that the school system to which he is exposed must equip him with the essential discipline of science and mathematics, in fact the whole range of these studies. With these ideas in the background, the new educational structure envisages the teaching and learning of science to be an integral part of the educational processes.

The application of science and technology will not only help to solve social problems but enrich the store of scientific knowledge and advance technological capabilities.

I have already submitted that science and technology grow not only by their application to the solution of problems but also by communication. Unless this knowledge is continuously transmitted, it would tend to degenerate into a mystique or become the preserve of a select few. The transmission of knowledge can best take place through the educational system, when the older generation initiates the younger generation into concepts and methodologies which have been evolved in the past and when, with the help of the fresh ideas and approaches of the younger generation, new ideas emerge. This interaction is thus one of the driving forces behind science and technology. An increasing number of educationists and government authorities all over the world have begun to take cognisance of the importance of this interaction by accepting the view that education, production and research must be fully integrated. This is not to say that research must only cater to the requirements of industry or the economic compulsions of a society or nation. The dividing line between fundamental and applied research is a slender one. The one without the other becomes meaningless and irrelevant. It is essential therefore that the balance, though delicate, is maintained and research made to progress in an integrated manner.

Thus, the knowledge and methodology of science must permeate the content of education; technology must be integrated with the educational process and education must provide an ever growing new dimension to science and technology.

Science and Planning

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The concept of economic planning was introduced by Lenin in the Soviet Union soon after Communist Party of the Soviet Union consolidated its authority. The economic planning became an important tool of the economists and political leadership of Soviet Union to speed up the economic development. Economic planning required surveys of natural resources followed by programmes of their utilization, which includes speedy development of infrastructure of transport and basic industries. Resources of the country were deployed towards specific objectives or targets of production or construction unrelated directly to the market mechanism.

Many other facets of economic planning came to be recognised in the process of implementing the various development plans. It became necessary to carry out extensive surveys of the geology, mineralogy, water and soil. It involved the assessment of the various technologies and combining those which could be most rapidly and economically utilized under the economic and technological circumstances pertaining at that time. Clear enunciation of priorities became necessary as resources were limited. In doing so, social and scientific considerations increasingly invaded planning. Social and political objectives apart,

social needs and ideals became quickly recognised as important factors in economic planning.

Economic Growth and Science

The aftermath of the Second World War brought about a recognition that the process of scientific planning can speed up recovery, give direction and greater cohesiveness to industrial and economic growth. This led to the OECD community of European nations to use systematic and scientific methods of planning. The newly independent nations of Asia and Africa were imbued with highly egalitarian social and political philosophies. They sought means for rapid economic growth and high employment. They also sought technological development and deployment of skills in various sectors of the economy. They desired egalitarian distribution of the products of industry and agriculture within the country.

This led many nations to take a closer look at material flows rather than costs and prices. Certain nations found controlling prices enabled them to ensure favoured material flows. It became quite clear that technology was very necessary both for the social and economic purposes of planning and development and for creating needed technical manpower. This led to a gradual increase of investments in research and development and as a consequence in manpower training in technology including agricultural technology. Over the last 25 years thus, these various processes have worked to give a greater content of science and technology inputs to the undertaking of socio-economic planning. The investment in the industry, agriculture, transport and education resulted in greater stress on manpower training and also generated pressures for modernisation of society in many nations.

U. N. and Science Planning

The U. N. was founded with brave hopes for the underprivileged but attention somehow went to the vanquished rather than the dispossessed. The hopes of some of the founders were not shared by others and science and technology in aid of economic growth or even growth of underprivileged nation did not become a serious concern until many years later. The seeds of unhappiness were sown in the UN Conference on the Conservation and Utilization of Resources in 1948. When this was followed by the UN Conference on the activation of science and technology for the benefit of the LDCs held in 1963, a sop was attempted to be given to the underdeveloped nations in that the Conference called for "continued attention by the UN on the subject of application of science and technology for the LDC" and suggested regional conferences.

Important recommendations concerning the relation of science to economic planning, the provision of manpower and finance required for scientific development and utilisation of science for economic growth emerged in a series of regional conferences entitled Conferences on Application of Science and Technology in Asia, Africa and Latin America. While these recommendations were unexceptionable in their wording, no attempts were made to go into case studies of China, the Soviet Union and Japan to understand the social and political imperatives that lead to successful utilisation of science for economic growth.

A further series of problems that came to light in the discussions related to the various features of relationship between the newly freed colonies and developed ex-colonial nations or in more conventional parlance the relation between the developed and the developing nations such as those of the

brain drain, import of foreign technology, the problems of developing indigenous technology, pricing of raw materials, patent problems, the relation between science, technology and production. A dramatic example of distortion of price factors was the price hike of crude petroleum by OPEC nations by more than twice, accepted by developed nations after threats and grumbling. Some of the elucidations of the ramifications of the import of technology led to a suggestion of setting up a permanent machinery for an establishment of a centre for transfer of technology for the Asian region.

Indian Planning

Indian planning derives from the time that Nehru set up the National Planning Committee of the All India Congress in 1936 and invited scientists, technologists, economists to advise him and the All India Congress Committee in generating ideas which would modernise India. After Independence, the Planning Commission was set up in 1951 to devise socio-economic plans in five-year sequence for the country. The techniques of devising planning have improved through the years and have been instrumental in developing a sound infrastructure of heavy industries and transport since 1956. Subsequently, agriculture began to draw greater attention when increasing population and stagnant food production became one of the bottlenecks of Indian development resulting in large imports of foodgrain from the USA and other countries.

Investments in agricultural science began to pay off only when the growth of new agricultural technology of hybrid seeds, fertilizers and water in the late 1960's began to generate adequate food supplies and the establishment of a buffer storage. Aspects of agriculture and its relation to social change were considered important and were increasingly

incorporated in the plans. While some progress was made towards social changes and in removing some of the glaring disabilities or disparities, the pressures towards social change have not been a sufficiently strong component of our socio-economic planning processes, particularly in the rural sector of our economy. The major resources of the rural economy are still in the hands of the rich peasants. In order to overcome this lacunae, during last three years, greater attention has been paid towards the rural development and the role of science and technology in that development. The Waltair Session of Indian Science Congress (1976) was the turning point in the history of science. The focal theme of this Session was "Science and Integrated Development". Our Prime Minister, in her address to this Session, pointed out that the Indian science should give itself a rural bias. She emphasized that rural life should be so enriched as to prevent the migration of people from villages to towns and cities. Proper planning implied acceptance of scientific attitudes by all people.

Due to his expectations from science, Nehru had tried to build an infrastructure of scientific organisations and increased the investments in science and technology. When the economic planning was introduced in 1951, the total scientific developmental expenditure was under three crores of rupees. During his own life time it had increased to around a hundred crores of rupees and today it stands at about 250 crores—somewhere around 0.6% of the GNP. Nehru had done a great deal to encourage the use of scientific knowledge and the scientific method for national planning. The number of Indian scientists and technologists also have increased vastly in this process and the qualified scientists and engineers of the country are today (re – 1975) in excess of 1.5 million. In fact India is the third largest country with technical manpower in

the world–a great asset to the nation. The impetus given by the Science Policy Resolution of 1958 added a certain mementum and has speeded the creation of a scientific infrastructure within the country which is comparable to many of the developed nations of the world.

Transfer of Technology

The benefits from these scientific investments have started to accrue to the country. Agriculture particularly wheat and to a lesser extent rice and some of the other crops have demonstrated the Indian scientists' capability of quickly absorbing science and technology development elsewhere and adapting it and applying it to Indian conditions. Some new innovations in agriculture technology have also appeared. Scientific research has been initiated in some pulses, fruits and vegetables. Other aspects of importance will undoubtedly receive more attention in the years to come. The Atomic Energy Department similarly began to absorb the technology of reactors from U.S. France and U.K. and the handling of nuclear materials became familiar. Both the skills and science have now matured to the extent of initiating building of indigenous nuclear power plants of indigenous variant designs. In fact except for enrichment techniques, most of the other aspects of nuclear technology have been absorbed and adapted for indigenous use. In the Defence industries a number of indigenous technological developments have taken place and the capacity of absorbing technology and applying them to the Indian conditions have increased significantly. The laboratories under Council of Scientific and Industrial Research have developed industrial products and processes, some of which are finding applications and attracting investments so that substitute products and processes and occasionally new products and processes are being increasingly introduced.

The overall growth and strength of Indian science have led to the question of whether the contribution of science and technology to the planning process is adequate today or needs further strengthening in the future. If the application of science has to be fully integrated then several things have to be ensured; one of them is flow of science and technology from one area or one agency or one discipline to others. The efforts at the Government level to bring about a greater flow of science in various directions and to ensure a greater integration of efforts led to the constitution of the Scientific Advisory Committee of the Cabinet in 1958 soon after the Scientific Policy Resolution was published, with Bhabha as Chairman. After Bhabha's accidental death in 1966 the Committee became moribund. It was reconstituted and redesignated in 1968 as the Committee on Science and Technology which tried to develop a science and technology data base for the planning process. The feeling that science and technology must play a more determined role in the economic planning process, led to formation of the National Committee of Science and Technology in 1971, which was given a specific charter to assist the planning process. It was separated from the Cabinet and attached to the Department of Science and Technology so that it could incorporate the views of scientists and technologists of the country in the planning role more effectively and enable the National Committee on Science and Technology to advise the Planning Commission in a more effective way.

Science & Technology and Future Development

The role of science in the future socio-economic development of the country requires a much greater analysis of the scientific processes than has taken place in our country so far. We have to recognise that science is not predictive and there-

fore in the planning of science one does not have goal orientation but rather direction orientation. In technology on the other hand goals are more specific and orientation towards goals are also possible. The nature of technological innovation is such that at best it takes place when there is a transfer of scientific knowledge or skill or a technique to another totally different area of technology, science or skill. This means that the most lively and productive kind of science and technology are those where there is much less rigidity in scientific structures, hierarchy or disciplines and where there is more mobility of scientists and technologists from one discipline to another as well as from one organisation to another and more operational flexibility of organisations to permit these to occur. Unfortunately there is insufficient attention to these factors. The rigidity and hierarchy of government seem to infect most scientific organisations. Mobility which ensures interactions particularly between universities and research agencies and between agencies are very restricted.

A valuable element of contribution of science and related technology is that one can develop a conceptual framework in which one is not completely guided by the classical economic nomenclature of capital intensive and labour intensive industries or agriculture. There is the possibility of low capital intensity and high skill intensity of highly sophisticated industries which can lead to high value production due to the high degree of skill incorporated into the industry even with low material inputs. The Japanese were the first to exploit this possibility and their electronic and optical industries were developed on the basis of low material requirements, low capital inputs but a high degree of skill being involved in the process so that the product value was quite high. To explore such possibilities one has to go into both the Internal social needs and export possibi-

lities as well as analyses of current or future technologies in satisfying these conditions under this low capital and high skill framework. The Government is providing incentives in the form of money, facilities and consultancy to popularize the establishment of new industries which would provide employment to innovative technologists and increase production in the small-scale private sector. It would be of some interest to consider giving priority and encouragement to skill and intensive technology in the small-and medium-scale sectors. Science and technology has given us some advantages as well constraints which need to be studied in industries such as computers, communication, food processing and fermentation, microbiological production, waste recycling and reuse. Some of these science based industries may have a more important role to play in future economic planning.

Minimum Energy Use

Minimum energy use for industrial or technological choices is going to be one of the important features of economic planning in the future. India is an energy deficient nation compared to China, U.S.A, U.S.S.R, West Germany and many others. It is important to emphasize in our R & D plans the exploration for possible energy minimising innovations to reduce energy needed per unit of production, particularly in those industrial processes which are today very energy hungry. One example is aluminium which is a highly energy expensive industry–a saving of 10% energy per tonne of aluminium is possible and can decrease the cost by 20%. In other industries the possibilities are even larger. Even the bicycle with its 10 to 12% mechanical efficiency oday has hardly undergone any significant change in the last 70 years. The bicycle is a very common method of transport and efficiency gained by a factor of two or three times will change the use of bicycles by human beings both with regard

to personal transport and with regard to transport of goods with very little increased non-renewable energy use. A 30% mechanical efficiency of the bicycle is a reasonably achievable technology. There are many other areas in which the minimum energy use concept can make a significant input into economic planning. The domestic chula has an efficiency of between 5 to 7% and 25 or 35% efficiency is not inconceivable as for example demonstrated by the Indian Oil Corporation's wick stove for kerosene. The inefficient chulas and bicycles cause waste of effort and inversion of values as the population which are striving most for economic improvement are saddled with the least efficient systems. Other examples of development of minimum energy use are those described as biogas, *i.e.*, use of wastes—agricultural, animal and human–for generation of methane through microbial fermentation and retrieval of the organic nitrogen and phosphorus from the residue as fertilizer.

In the planning process choices of technology are all important. This leads one to problems of technology forecasting. With all its limitations some kind of extrapolation of technology which is not entirely a linear extrapolation can be a very useful component in devising choices for socio-economic planners Since forecasting of technology is, to a large extent, based on the current achievements of science, it enables technological innovations to be speeded up if it is used with clarity and wisdom.

Another feature of science which will increasingly impinge on the planning process in the years to come are the ecological constraints on socio-economic planning. Today we try to remove pollutants or devise methods of taking care of the pollutants from industry or agriculture. However, much of our developmental processes also affect other balances of nature in a variety of ways. Cutting of forests

for paper mills may also cause serious disturbance to certain species of plants or animals or cause the denudation of hill slopes. These ecological constraints need to be considered as a part of the planning process so that in future environmental considerations and developmental planning can be interwoven into a single planning matrix. In a country like ours, the environment is already under certain stresses due to over-crowding, denudation of land, intensive use of water, rapid industrialisation and loss of forests and wild life. Developments cannot stop, but further degradation can be and has to be prevented. In future we cannot conceive of trying to correct the degradation produced by human activity after it has taken place. Preservation and improvement of the environment will have to be carried out concurrently so that the expansion of human activity does not extract a toll which is remitted to future generations ; problems which can make their life and their growth more difficult than ours has been.

The renewable resources of the country can be used in a manner in which these resources are also generated at a rate not less than the rate at which they are being used. However, where non-renewable resources are concerned, apart from energy resources such as coal or oil, the problem of recovering metals and other non-renewable materials is an important one for maintaining high economic growth rates in the future. A large part of aluminium now in use can be recovered by proper social methods. The cost of reutilising scrap aluminium is a small fraction of the cost of producing fresh aluminium and therefore it becomes a far more economic resource which is lost if this kind of recycling is not built into our social system. This type of recycling and reuse possibilities apply to many items of use, such as paper, cardboard, polymers, metals, glass and ceramics. Methods of

collection, sorting, selection and processing require some investigation and research to elicit those which will be economic and require less labour. The cost of recycling these materials are a small fraction of their initial manufacturing cost and can make such recycling an economically viable proposition if social behaviour and technology can be properly organised.

Even more important than the economics of the system is the value of recycling because it reduces waste on one side and adds to the production without greater demands being made on our environment than one would if one has to process raw materials and use them.

A nation's economic plans are determined by a country's aspirations for a better life but it is also constrained by the general level of development, its geographical situation and its social and economic system. When one tries to achieve a policy for development of a society as a whole, science is not independent of its broad social, economic and geographical context. Science therefore has an enormous possibility of contributing to this development if it can accept local or national problems as legitimate scientific objectives. This is not only a gain for science itself, it is also a gain for the society. A prime example is the use of scientists and technologists for the development of Siberia. They live and work there. They derive their problems from their environment and in the process are developing the vast Siberian hinterland of the U.S.S.R.

There is, however, often a concept that science is something to be pursued in isolation and it is preferable that social interaction be feeble. This concept of science, for its own sake, has a great deal of attraction for many people. It encourages a kind of withdrawal from the society and social problems. In our country, the attraction is even more

powerful because of the close similarity of this attitude with social traditions of withdrawal and non-attachment. There are serious risks in the excessive promotion of such ideals. First of all, there is a basic relationship between science and society. Primarily, science and scientists require money and technological support to carry out their tasks and this has to come from government and society. Unless there is a clearly seen benefit to society from science, this resource can tend to dry up. Secondly, the scientific community in a society is a strong lever when properly oriented for changes in social attitudes and in the modernisation of a society. All progressive governments like to see that this progressive force is deployed effectively and hence the support to science. Any symptom of non-attachment can carry the implication that the scientists are abdicating their role of advocating modernisation of their society. This can often bring about a social disinterest in science.

The planning process in the country can use science far more effectively than it has in the past. Planning requires scientific knowledge. It applies the scientific method. It needs scientific and technical skills in implementation. Above all planning requires a scientific attitude on the part of those who plan, those who implement and those who benefit. Beyond this, carrying out a plan requires from the scientists as well as social scientists a great deal more of dedication, understanding and social commitment than has been forthcoming in the past. Scientists are too concerned with maintaining the rigidity of their scientific structures and hierarchy, too concerned in becoming a part of the political system, and not enough concerned about making inputs into the processes of change in our social, technological and natural environment which are a part of the process of carrying out socio-economic plans.

Science and Morals

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Our age has seen many acts in the major drama: of man having created more knowledge than ever, through science, and the possible near destruction of the human race through that very knowledge. Perhaps, one of the penultimate acts of this epic play is being enacted in the Salt conference, where the two superpowers are engaged in discovering certain formulae on how to limit their stocks of the latest and most devastating missiles.

The questions of parity of strategic weapons like the Mirvs (how many, and what for, and with what range) are being asked. These questions have to be resolved, as also the question when the bombs will be defused, before human beings can breathe a little more freely, without the danger of being wiped out or maimed in large areas, through the accidental beginning of an atomic war.

Underneath the acceptance, by most people, of the giant arms race, there are vague fears, which affect the minds of even those who don't know all the facts about the dangerous potential of the latest weapons.

The older generations, who have seen the first two world wars, seem to be resigned, since their life spans seem to be nearing the end.

But there is a decline in the birth rate of the most advanced countries, one of the contributory causes of which may be the fear of mothers that their children may be destroyed in a new Armageddon.

Quite a few of the young want to opt out of society and search for a new consciousness.

The club of Rome intellectuals have asked for a "zero growth" until the year 2000.

The Pugwash scientists have warned mankind about the pollution of our planet, the precipitate exhaustion of raw materials and the change of weather through atomic tests.

And though, on the surface, there may seem to be slowing down of the protest movements, there is intense moral concern everywhere about the relations of man, science and morality.

A number of questions are being asked :

Should not science, which creates monstrous instruments of destruction be stopped altogether in the face of the potential hazards ?

Are the scientists, who sell their professional knowledge to the politicians of their respective states, not guilty of treachery to the human conscience ?

Is it possible to evolve a new set of principles of morality to cope with the situation which we witness, of the possible death of a whole civilisation, through some mistake by a fanatic, who may throw a small atomic grenade and start off a chain reaction that may wipe out the whole earth ?

All these questions are inevitably ethical questions, even if the morality to be evolved, will depend on the psychologies, normal or perverted, of the various elements involved.

Unless we achieve some new guidelines, the profession of science will be in the invidious position of being rejected by the religious orthodoxies, which have often been obscurantist, and new knowledge and experimentalism will be at a discount.

In order to demonstrate that all human societies have had to make some guidelines to survive on earth, in every kind of civilisation, let me put down here, the basic postulates of civilization itself.

Since the four-legged apeman began to walk on two legs, and went out to look for food to sustain himself and his family, he had to seek certain conventions, about his relations with others.

The first need of man seems to have been for sheer physical survival. So our great-great-great-great - *ad-infinitum* ancestor, began to hunt, *together* with other men, so that the combined strength of the group may be more than equal to ferocity of the beasts he had to kill.

And, in order to protect the female folk, who stayed at home and looked after the children, the caves or shelters were so placed as to form a hamlet. The shelter of the family itself was made in such a way that outside threats and climatic hazards could be avoided.

The fetching of water from the pool, or the stream, or the river, was rendered possible by making of tracks through pooled labour.

The instruction of the young, in shooting arrows from bows, learning signs, and looking after the cattle, and, later, cultivation, was put in the hands of the oldest and most experienced man, probably the bard.

The forest land from which the food was gathered was held in common. And the conventions about the rights and responsibilities of the various families were established on the basis of the size of each family and their human needs.

This early social order was, therefore, a moral order, in which certain guidelines about the relations of one man to another were determined by the individuals together with the community.

The basis of all early civilisations was mainly the means of producing the wherewithal.

The subtle area in which the body-soul was heightened was not neglected. Almost instinctively, primitive man seems to have reinforced his will to hunt by enacting the desire image, the kill of the beasts, on the walls of the caves, in red-hot ochre or lime paint, in vital strokes, almost as he shouted and pierced the fancied beast with his imaginary arrows. These pictographs may have something to do with sign language. At any rate, the ritual of the drawings on the walls, was a kind of experiment in the primitive laboratory, to achieve the magic power, or knowledge, about how to get the food.

The relation of the fundamental laws, which governed the life of the community, implicit in any civilization, are so integral to the needs of people, that these rules have lasted out in the most complicated societies of the world, and even the most highly intricate industrial civilizations seem to be governed, ultimately, from the smallest cells, under rules which are organic to life processes.

It is only because the gargantuan power states of the world have tended to ignore the cells below, and ride rough-shod over considerations of human decency, enshrined in the brotherhoods and sisterhoods of the small communities,

based on the mutual age, that the present deep crisis of mankind seems to have arisen.

It is quite likely that the core of the morality of primitive civilizations was affected by feudalism, by one-man rule, then by the imperial systems and later by the bourgeois democracies, themselves affected by the infighting of cash nexus interests. Thus the moralities we have today in the various parts of the world are often contradictory.

There have been empires based on the 'white man's burden', and won by the use of gunboats and automatic weapons, against unarmed peoples. As against the aspirations of non-violence of Gandhi, there is the assertion of the American Robert Audrey, that 'man must occupy space' and 'use force inevitably from his nature as a fighting animal'. And there is the recent reassertion by small bands of guerillas of an old adage: 'an eye for an eye' and a tooth for a tooth'!

In fact, in most democracies, the rights of the few seem to be more important than the rights of the many. And we are face to face with the vast intricate quarrels of those who believe in private property, and those who believe in more egalitarian systems of mutual aid.

In such a situation, it may not be possible immediately, to evolve a new moral order, which may allow science to pursue its experiments freely, but which may itself offer to protect the people from the hazards resulting from the utter disregard of consequences of scientific discoveries.

All the same human beings have to achieve some kind of balance between the supposed benefits of science and the future hazards.

What is the exact situation today ?

It seems that conflicts are sought to be resolved through the *detente* between the two super powers, U.S.A. and U.S.S.R. And it is likely that a third world war may be avoided.

But it is unlikely that the fundamental difference of emphasis between the Profit society and the society which made the first essays in Mutual Aid, can be adjusted, for decades to come.

The main structure of civilization will go on. But the world is torn into two, The cleft is in the middle. We all live in a state of ambiguity between two worlds, one dying but not quite dead and the other refusing to be born.

The world does not change always through a big bang but, perhaps, through millions of small whimpers. Opposites often tend, through thesis – anti-thesis, to form synthesis.

The world process is too chaotic to admit of any generalised statements as to how the two contradictory systems can whittle down their basic postulates and become a uniform world order, converging towards a possible common emergence. Neither side, in the giant confrontation, will give up the habits to which it has become inured.

On a recent visit to the U.S.A., among the many sidelights I witnessed, I lived for three months in the political madhouse created by the election year.

Let me reproduce a cutting I took from *Capital Times* of Friday, November 7th, 1975, a big broadheadline :

Peace Built on U.S. Sale of Arms—Kissinger says

The report was from 'Washington (A.P.)' and read :

'American foreign policy is now openly rooted in the theory that world peace requires U.S. fueled arms races abroad.

'Secretary of State, Henry Kissinger, signalled his position, Thursday, in testimony before the House International Relations Committee, on the administration's new Foreign Aid Bill.

'All foreign policy begins with the security he asserted.

'The possibilities for reaching peace by restricting arms sales to other countries are diminishing, he said.

'Instead, regional stability is increasingly bound up with the maintenance of stable balances of power, through carefully considered transfers of defence equipment, Kissinger said.

'Translation: More U.S. arms supplied round the globe is the way to peace and order.'

'Kissinger came to this conclusion by using this logic:

'This is a world in which the level and quantity of international military transactions will be substantial', he said.

That is straight from the horse's mouth, as they say, without any equivocation, subterfuge or disguise.

And, behind the State Department Secretary, are ostensibly the multinational companies, geared to making profits through the biggest armament manufacturing industries of the world, except that of the U.S.S.R.

Almost, everyday, there is an announcement of fresh U.S. arms sales.

As I sat down to write this text, I saw in the *Times of India* a comment on the discussion in U.S. Congress that, after selling ten billion dollars worth of arms to Iran, since 1972, the administration is selling four billion dollars worth more arms to the Shah, who feels somewhat insecure and wishes his country to protect its independence, and to play its legitimate role as the principal ally of U.S.A., in the region of the Arabian Sea. Furthermore, the U.S. has decided to sell five hundred and seventy-three million dollars worth of military hardware to Saudi Arabia, obviously because Ibn Saad also feels somewhat insecure in his perch in Riyadh !! And there is another eighty-four million dollars worth of aid for Mr. Bhutto, who has been feeling so insecure since he became a politician, that he has helped to initiate four Pakistan wars against India during the last twenty years ! ! ! ! And, of course, South Africa feels much more insecure than anyone else, because the blacks want to be taught a language which they prefer, while the whites want them to become civilised through their own favourite tongue ! ! ! And the Chilean junta feel utterly insecure, even after they have murdered almost the whole opposition, and want to be fortified to defend the C.I.A. sponsored new order ! ! ! ! !

In fact, the bulk of the U.S. economy is being refurbished by the manufacture and the sale of arms. That is why there must be a crisis every third month in some part of the world, and a possible war every year, to keep the home fires burning. Currently, the concentration is on Lebanon, where brother kills brother, with a relentless fury, which has totalled several hundred thousand dead, and reduced the once flourishing city of Beirut into debris.

The immorality, which results from a profit system, that seeks to survive on the sale of arms, accrued as huckster's profit, to Zaharof and other merchants of death before the

first world war. They made millions by a cynical contempt for human lives that were lost in that blood bath. Again, we saw how Krupp and Thyssen and Sehneider bribed the Hitler gang and took up the programme for rearming Germany, making it the greatest military power of that time in Europe within five to seven years.

And though the British capitalists had imposed an unequal Versailles Treaty on the liberal Germany of the early twenties, they themselves gave to the Fascists the Anglo-German Naval Treaty, in order to sell ships to the country which was ultimately to fight them. The twenty-five million soldiers, who died in the second giant world blood bath, and the twenty-five million civilians who perished, plus the six million jews who were tortured and done to death, sometimes stare at us through the celluloid documentaries of those days like *Mein Kampf*. They remind us of the near extinction of human values that has occurred on a world scale, mainly through the greed for profits, twice in one generation.

Those who believed in egalitarianism and broke away from the Imperialist-Capitalist social order of the West, in the U.S.S.R., had to face the persistent contempt, hatred and vilification for the last fifty years or more.

At first the Capitalist States, singly or together, imposed a civil war on the infant Socialist State, which was emerging under Lenin.

Then, there was a sententious propaganda against the U.S.S.R., for its lack of those privileges which the cash nexus society had given to the highly industrialised capitalist countries. The Western women were told that the Russian females had no lipstick, which was true, because they were busy cultivating harvests for food. The Western men were

told that the Russians had no freedom when the Soviets defined freedom as 'recognition of necessity.'

Of course, the hostility of the Capitalist world, with its many provocations, actually succeeded in bringing about equal spite from men like Stalin, not only against the West, but even against those Russians who wished to emulate some of the liberal values of the old world.

And, as some of the leading Capitalist states tried to incite the Fascists against the U S.S.R., helping them to build up large armouries, Stalin began to arm the Soviet Union, at the cost of neglecting the growth of the socialist economy beyond basic plenty.

The strengthening of military of Russia was justified, under the proletarian dictatorship, by the assertion (ultimately proved to be true), that one day it would have to defend itself against the war-mongers from the West.

Those of us, who saw the permutations and combinations of the power struggles before the Second World War, including the Soviet-German Treaty of 1939, have realised that the centralised power states of the world, whether capitalist or socialist, have to play the game, imposed on them by the struggle for power itself.

We have seen how, after the disasters caused in both the West and the East, through the prolonged seven years of the Second World War, the West began, through Churchill's Fulton speech, a cold war, which has imposed a gigantic armament programme on the U.S.S.R. And this has made Russia today the near equal of the U.S.A., in the stockpile of the potentially most devastating weapons ever invented by science.

What is the relevance of morality to the situation in which science has helped to decree death to mankind and the extinction of our planet ?

The new ethics, if there is such an ethic, has to prove itself by becoming the agent of change and not remain an epiphenomenon.

Morality is clearly derived from the social pressures of any given time. Said Frederick Engels : 'All the driving forces of the actions of any individual person must pass through his brain, and transform themselves into motives of his will in order to set him into action' !

The good is not dependent on the 'survival of the fittest theory' of evolution, but in the shaping of evolution itself. Peace is morally good, aggression is morally evil.

The development of the moral sense beyond the old societies has been hindered through the emergence of man into a new world of nuclei, quanta, electronics, relativity and electro-magnetic waves. These abstractions have taken the many inventions of science into a sphere beyond the daily life of man, even though they have changed the conditions of his existence. The kind of brain a human being has inherited is, in the ordinary way, unable to grasp the by-products. We could all understand monsters, gods, and spirits but cannot understand what is 'fallout', what are its effects and dangers. And the 'millions of megatons' we mention has little meaning for the mind used to the fire in the cave, the grate or the oven. We are still affected by the suffering of a sick member of our family, but we cannot easily sympathise with the pain of a million or more people affected by the atom bombs thrown over in Hiroshima or Nagasaki. The 'pulverisation' of a city is a mere phrase to the man in the street.

The moral sense about the vast terrestrial forces which the scientists have unleashed, can only be aroused if we pose before the world the simple question of the potential death of a large part of mankind, against the remote possibilities of its survival. And while the scientists try to release this cosmic force of the atom which they can release at any given moment, they must think out how this force can be arrested, quarantined and defused.

How, then, are we to evolve a moral code beyond the simple one which says 'my friends are my friends and my enemies are my enemies', 'my country right or wrong', or 'my family or tribe or nation against all outsiders'. And we have to see that the whole of mankind is on one side and the neutral bomb thrown by some insane fanatic is on the other side.

As I have suggested, this can only be done when all societies, based on the profit system or mutual aid, agree to consider killing of a fellow human being as the greatest moral evil.

The mentality, which we have inherited from the past when the man who killed many people was a hero, has to be discarded in the minds of children from their early school age. The very idea of mass murder in war must be made abhorrent to the new young. The discrimination against conscientious objectors must be penalised by law. The dualism by which a white man is punished for killing another white man but pardoned for killing a black man, has to disappear. In fact, we have to evolve universal human values applicable to all groups.

This means that the scientists of the world refuse to work for any government which is not willing to abolish the deadliest arms to begin with. And the education system of

the world must be informed by the passion to banish wars for ever from the earth, in the air, or in the strathosphere.

The balance of terror, built up by the U.S.S.R., has then to be used for the progressive realisation of a morality of a world with lasting peace, if the egalitarian ideals of the Russian Revolution are to be furthered to any extent.

At the moment, however, through the dialectic of their opposition, the scientists of both sup r powers, are building up every conceivable weapon, not only bombs, but weapons of chemical warfare, drugs and techniques of psychological brain washing, which are likely to affect human life and make it abnormal in many respects.

The saturation point of the arms build up has been reached and no ethical consideration is being held valid by the bomb-exploders.

Let me quote the Nobel laureate, Prof. Linus Pauling, on the radiation effect of nuclear tests :

'Normal background radiation', he says, 'is responsible for about 10% of all gross physical and mental gene radiation and I am sure no one would want to increase that.

'For every twenty megaton hydrogen bomb exploded in the atmosphere, five hundred thousand unborn children would suffer gross mental and physical defects and the same number would contract cancer'.

Unfortunately, the scientists of the French High Commission for Atomic Energy claim, as against Prof. Pauling, that the French nuclear tests would not produce anything more than normal background radiation. As we all know, the French are known to be a highly polite, civilised and cultured people, and their bomb cannot help being a polite and civilized and cultured bomb !

There is no gainsaying the fact that the proliferation of the bomb has diversified the moral issues involved. The super powers no longer have the hegemony and they would not wish to become victims of one of their own clients to whom they might sell a bomb, and who might, sometime or another, turn turtle, and throw a bomb on either of them in a guerilla attack.

Also, if the power to make a bomb, and thus to indulge in scientific experiments, becomes widespread, then more countries will be involved in thinking out a code of conduct about inventions of all kinds.

This will not happen, all of a sudden, by a U.N.O. resolution being passed to evolve a new morality. There is no promised land on world Utopia in the offing.

The process can only start when the so-called common man begins to think of his future in simple human terms.

I asked the person who was taking down these words :

'What do you want from life' ?

She answered : 'Happiness. I want to get rid of my allergy, so I can breathe fresh air which means I want good hospital, and doctors and consultants. I want some money for my shelter, food, clothing and books – but not too much, so that it is all taken away in income tax ! I want to hear music. I want to go for a long walk in the rain, holding hands with someone. I want to live and go places and meet people. And then I want to write a funny book about people like you, who only talk of peace and highmindedness and morality and do nothing to achieve it for yourself or for us...'

I answered back : 'What about you trying to achieve it'?

She asked, 'Where do I start?'

I answered: 'By welcoming all those things which make for happiness, like love one another'!

At this juncture, my thoughts went back to the morning paper, where I had read of Dr. Khorana's breakthrough to the new gene, which might lead to several scientific inventions, to help the sick, to produce food and to prevent pollution.

Similarly, when I remember the lack of enough power to make minimum things, for basic plenty, for three-fourths of the depressed populations of the world, I feel that the use of atomic energy, only for peaceful purposes, may be possible if the world scientists accept this as a universal principle.

The simple wants of most people in life indicate that, in the evolution of a morality or a code of conduct for scientific discoveries, the ordinary people, whose smiles are necessary to keep the world going, must be inevitably involved.

Thus we get back to the people in whom the ultimate sanctions lie, for any change from the breakdown of morality and human relations to the evolution of the bylaws for human survival at some level of decency.

But the people by themselves, as they are brought up in the thousands of years of poor evolution, under feudal terror, one man rule of bejewelled monarchs, or steel kings and their nominees, and the survival of the fittest idea cannot grow into awareness of the need for decency, to live and let live, until they acquire some idea of themselves and others.

The noble theorem of Christian religion, 'Love one another', has not been practised much in history, because

most people have not been given the opportunity to know themselves and their near or far neighbours.

Perhaps, then, a new kind of education for a new consciousness of oneself, and the cosmos in which one is placed, is necessary, to evolve the new morality.

And, what will be the syllabus for this new education for the new consciousness?

The syllabus may absorb the information built up through the explosions of knowledge of the last five hundred years. But, it will have to put at the core of the whole system, the questions: 'Who am I'? 'Where do I come from'? and 'Where am I going, along with the millions of living beings'? In fact, what is the goal of evolution? And what are the truths revealed by science to control it? Are the scientists to give us larger quantities of food and other basic necessities of life, or are they also to improve the quality of life? Is it possible to question the gift horses in the mouth, given by the scientists, to avoid the pollution brought by the growing science and technology? Is the whole world to copy the aggressive Faustian Western culture or there any counter cultures available? For instance, is it possible to decentralise the power state, and get back to the well-knit, intimate village and small town communities, like those of Gandhi's vision and the Kibutz style nuclei, or the new American dropout settlements? Is it possible to limit the unbridled profit motivated growth? Or to humanise technology?

The answers to these questions will come even as the processes of counter cultures grow spontaneously, under cover of the reprieve for mankind brought by the balance of terror.

But we must get back to the still centres of contemplation in schools, colleges and universities and talk to each other about how to limit the stranglehold of authority, how to dissolve power, and how to carry on the Wellsian 'open conspiracy', to rescue from the hocus-pocus of myths like 'we can bring rain by prayers', to the faiths which rely on a religion without religion.

There is also the need for education through a continuing seminar all over the world, about man's achievements so far and his failures. In my opinion, the achievements have been less considerable than the failures. The potential of knowledge was bigger, if the various parts of mankind had adopted mutual aid as the ideal and curbed the cash-nexus order imposed by the self-aggrandisement of multi-national trusts to control the world. But, through the cynicism of the people, in the face of the toughnecks, the surrender of world democracies to the power states is more or less complete. And we are, as you all know, going through a new dark age.

The individual has to retreat, therefore, to the seminaries. There he must seek self-knowledge to integrate himself. And working within small groups like the village and the small town, he must accept the life giving sciences, away from the present rat race of the insecure, who want bomb and missile technologies, which they can't even use. And he must reach out towards a body-soul, inspired by the urges of humanness, which will itself suggest the kind of rules of conduct we may establish as norms of decency in our relations with other men and women.

The transformation of consciousness will not come through the big bureaucracies, nor through computer programmes. nor through mere job hunting with Ph.D.

degrees. and the lust for grades and motor cars and 'living up to the Joneses'.

The liberal era, discreetly inspired by the spirit of the *laissez-faire* profit society, generating vast industrial complexes, and even the Stalin kind of dictatorship, is reaching its end everywhere, through the very fact of universal insecurity in spite of the arms build–ups. I am not unmindful, however, that the illusion of affluence remains a romantic dream of people in the newly freed states. The Babu wants the gadgets which the Sahib has. And the rich peasant wants to become a sugar planter of the old type of the Imperialist period. The intellectual, whether scientist, or a professor of the humanities tends to emulate the example of the elite societies of the West and seems quite content to escape into the comparative seclusion of the universities, so long as he can be elected to the aristocratic managerial syndicate and the senate The creative writer is inclined to retreat to ashrams. and though he renounces authority, he accepts the ancient patriarchal man-god Guru. All these contradictory things are happening because, though the cash-nexus society is finished, it is not quite given up. And, in the ambiguity. the protagonists of socialism want to share power with the industrial magnates, the big landlords and the new class of bureaucrats.

I am inclined to believe that. in our society, we can only evolve a new morality for science. or for any other part of human life. by evolving a new constitution, through a new constituent assembly to bring about a participatory democracy from the grassroots.

I am for the autonomous village. with a new Panchayat. planning its own life. and applying science organically. to ordinary life to send the surplus to the small town. from

twhere it will get its machines, and where it will be represened in the Zilla Parishad.

I am for the Zilla Parishad, planning its life in relationship with the village and big town and sending its representatives to the state legislature.

I am for the Vidhan Sabha legislature, which may include representatives from the village and small town, as well as from the city itself.

I am for a new Lok Sabha, which will really represent the Lok–by bringing peasants, workers, small industrialists and big industrialists, plus 25 per cent intelligentsia, to New Delhi.

In fact, I am for an Indian style cultural revolution, which will evolve a new life, with a new human morality, from a new consciousness of the relations of man, science and human needs, aspirations and dreams.

Science and Technology

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1. One of the characteristic aspects of the 20th century is the pervasive influence exercised by science and technology in almost all aspects of human endeavour. These have become the first concerns of governments, whatever be their political philosophies. This is apparently because, in modern times with exploding populations and an incessant pressure to increase the standard of living of people all over the world, application of science and technology seems to offer the only alternative open to governments to satisfy their people's requirements. It is primarily in this perspective, one has to appreciate the concern of governments to establish strong foundations for science and technology.

2. In earlier times, pursuit of science was the preoccupation of a privileged few. They pursued it as an end in itself. The edifices of science were built as a result of a few individuals satisfying their intellectual curiosity. These concerned themselves with empirical observations of nature, putting forward hypotheses to explain the new observations and conducting tests to confirm or deny the hypotheses. It is a rationalistic approach to perceive order in nature. In passing, it is interesting to note that whereas the intellectuals in ancient India used their reason by and large owards theological and philosophical speculations, their

counterparts in the western world used their reason to a greater degree for obtaining a better understanding of nature.

3. One cannot discern any directly observable relationship in the growth of science in the western world in the earlier times and the concurrent growth of technology. James Watt or George Stephenson did not wait for the enunciation of the principles of thermodynamics before they developed a steam engine or a steam locomotive. However, one can also notice the fact, in those countries where science did not have strong foundations, technology also did not grow strong foundations. One is therefore tempted to argue that there is something in the culture of science in which technology can grow. In fact contemporary developments in technology would not be possible in the absence of strong foundations of science. It is inconceivable that the developments of the transistor or a laser would be possible without the basic researches that preceded them. It is equally inconceivable that aircraft, nuclear power, and modern electronic devices and systems would have been possible without the enormous amount of scientific research that preceded these technological inventions and established the bases for them.

4. The developed countries with fairly high standards of living are characterised by strong foundations in one or more branches of science and technology. The base for the growth of technology in these countries is internal and self-generating. It does not normally depend upon imported know-how. One could also notice that when once such a base is established, it has a decisive effect on the growth of the broad industrial base in the country through the horizontal transfer of technology from one discipline to the other. In such countries where technology is imported from another country, it also tends to take roots more quickly and forms

the basis for the development of the next generation products.

5. To the extent the technology is native to a country, it reflects the life styles and social values of its people. Thus, for example, in a country with a relatively smaller population and high cost of services, it is most likely, the technology will be capital intensive and requires consumption of sizable amounts of commercial forms of energy in the manufacture of the products. Production will be geared to producing labour saving devices to help the householder and these in turn will also be intensive in energy utilisation. Automation and high energy consumption both at home and industry are typical of such countries. Even in agriculture, these countries will tend to follow similar patterns. Utilisation of labour saving machinery, extensive application of fertilizers, pesticides, etc., will be more a rule than an exception in such countries. In a country where the labour is less expensive and unemployment is high, capital is scarce and there is pressure to create more and more jobs, it is more likely, the indigenously produced technology will be labour intensive.

6. It may be noted, that as far as India is concerned, although university education is more than a hundred years old, except for a few isolated instances, studies in science and technology have not made much of an impact on the country. What little industry was there, was based upon imported know-how and continued as isolated pockets of industrialisation in a country which was otherwise predominantly agricultural in its economic base. The scientists, such as there were, took up either teaching or administrative positions. By and large, research in Indian universities in the fields of sciences was relatively scarce and tended to be unrelated to the national requirements. Neither scientific

research nor technology was grafted to the social and economic fabric of the country. Except possibly in a very few instances, the few centres of scientific excellence did not really make the kind of impact one could have expected from them on the scientific and technology base of the country. In fact it was not uncommon that more people from abroad knew what was going on in some of these places than their own countrymen ! The problem has been that in the absence of an indigenous base for the growth of technology, indigenous scientific research stood alienated from the Indian technological scene and became imitative.

7. Notwithstanding this, the base for scientific and industrial research was however getting to be established through organisations like CSIR even before the country obtained independence. However, their activities too, by and large, continued to be academic with a strong influence of the university environment from which many of the scientists who occupied senior positions of responsibility came. The performance of these institutions more often than not was assessed by the number of papers published and number of people from these institutions who obtained Ph.D.'s while working as staff or research fellows.

8. The ushering in of the Second Five-Year Plan highlighted certain important aspects of the Indian economy. It is that, while the Indian economy will continue to be based substantially on agriculture, a decent increase in the standard of living of its people will only be possible with a degree of industrialisation. It is also recognised that while the import of technology will offer rapid start towards this end, continued import of know-how can never be the enduring base for obtaining a measure of self-reliance in the country. Cultivation of scientific temper and the culture of science in which technology can grow therefore assumes great

importance. As the science policy resolution of the Government of India of 4th March 1958 stated in its starting paragraph, "the key to national prosperity, apart from the spirit of the people, lies in the modern age, in the effective combination of these factors – technology, raw-materials and capital, of which the first is perhaps the most important, since the creation and adoption of new scientific techniques can in fact make up for a deficiency in natural resources and reduce the demands on capital. But technology can only grow out of study of science and its applications"*.

9. With the acceptance of the science policy resolution and the industrial policy resolution, India, apart from its desire to increase the standard of living of its people, has implicitly taken a decision to transform itself from being a developing country to a developed nation.

10. The science policy resolution is essentially an expression of faith and an acknowledgement of the fact that while the Indian economy is primarily agriculture based, a decent standard of living for its people can only be obtained by the recognition of the place of science in the Indian educational system and the application of scientific methods to solve the multitude of problems that are inhibiting the national growth. However, as Prime Minister Shrimathi Gandhi pointed out in her inaugural address to the Third Conference of Scientists and Technologists and Educationists in 1970, it was not a blueprint of a well defined programme for implementation, but only the Government's resolve to provide continuous support for science.

11. The support for science by the Government was based on the faith that somehow such support will offer the infrastructure in which further growth of science and

* Appendix : Science Policy Resolution.

technology can and will take place. Clearly, what is really needed is not simply support for science but the use of science and the infrastructure built for it as a tool for national planning: Otherwise scientific R & D institutions quickly tend to take up fashionable research, imitating what is going on elsewhere than tackle problems of national relevance. In the absence of clearcut national objectives, the staff of these institutions will tend to work in areas of research of their choice instead of responding to the changing needs of the country. R & D institutions can then quickly become luxuries which we can ill afford.

12 The National Committee on Science and Technology (NCST) document identifying areas of primary thrust in R & D in various sectors of science and technology is perhaps the first systematic attempt in the country to involve the scientific community in planning for science and technology. Something like 2000 scientists and technologists have apparently participated in the exercise. While some criticism can be levelled against the proposals, it was nevertheless an important effort to relate planning for science and technology to the national planning.

13. The main weakness in NCST was that it has only advisory functions and to that extent its recommendations were not necessarily binding on the various departments. It has no control on funds. It is not entirely clear that the Planning Commission itself took to heart the recommendations of NCST and used them as primary guidelines for plan allocations. This is in contrast to the functioning of the State Committee for Science and Technology in the Soviet Union. There it appears to be much the spokesman and arbiter for the Soviet Government in so far as planning for Science and Technology is concerned. It effectively utilises its authority through financial inputs.

14. NCST is also apparently weak in another respect. The plan was as conceived by specialists for their particular sectors. It was additive. One searches in vain to obtain a clue to the inter-sector priorities which determined the suggested allocations. If the plan is to respond to the needs of the people, it can perhaps have, as a starting point, a definition of the minimum needs of the people from which the per capita income increases could be defined. These in turn would form the basis for setting targets in various sectors.

15. From such projections one could work back to the production requirements in major sectors such as technology, energy and food. While admittedly such an approach for planning for science and technology is perhaps more difficult, it will have greater relevance to human needs and can crystallise the relevant areas of research in science and technology in a far more specific manner.

16. The dilemma for the Indian scientists and technologists and for that matter of fact for the planner and the educationist is to decide what areas of science and technology are worth pursuing for a country like India. If it wants to become a developed nation, it must concentrate on at least a few areas of high science and high technology. The choice is so large, that unless selection is made carefully, we can easily lead overselves to disaster. Areas of high science and high technology are normally capital intensive, labour shy, have long gestation periods and built-in technological obsolescence. Research in these areas is highly competitive all over the world and an enormous amount of work carried on in one country in a particular area can be made obsolete overnight by developments in other countries. Its dynamics are therefore set on world scale and not on a national scale. There is an element of risk in them, but if the gamble pays off, the benefits are enormous.

17. The rate of transformation of the economic base can be substantial and nothing can boost the confidence of a nation as successes in a few selected areas of high science–high technology. In India, one can cite as examples, the nuclear explosion and the Aryabhata. Through their impact on the country, some of the areas of high technology such as satellites can revolutionise a country's whole pattern of growth. It has been estimated that if an adequate task of teaching of the millions of Indian children distributed through more than half a million villages, towns and cities is to be attempted through traditional methods, not only do we not have enough teachers, we do not apparently have even enough training institutions to train the teachers who will teach the students! Carefully planned educational programmes on satellite television offer exceptional possibilities under such circumstances. They will also offer exceptional tools for natural resources surveys and through false colour pictures give invaluable aid to spot diseases in plantation crops. to determine the extent of produce of various agricultural products, etc.

18. Aeronautics, electronics, space and nuclear research have been the pace setters in the developed world for the increased rate of growth of technology. It would appear that we can ignore many of these fields only at our peril. India has the wherewithal and the potential for belonging to the class of developed nations and it would not be possible without paying attention to these fields.

19. Many of the fields of technology which we have to usher in in order to obtain a measure of industrialisation and self-reliance demand large amounts of commercial forms of power. In fact several tens of thousands of crores rupees worth of investment is called for before the end of this century. The fact of the matter is, non-availability of a

rupee worth of power can bring to a grinding halt about Rs. 10 worth of industrial machinery and result in loss of production and idle and unemployed manpower and correspondingly inhibit the growth of technology. The prime prerequisite for technology is power. Without power, introduction of many of the areas of high science and high technology will not be possible. And without these, this country cannot become a developed nation.

20. The patterns of economic growth based upon low or no science and technology have also their shortcomings. Solutions to some of our really critical problems will not be possible without application of science and technology. To illustrate, let us take the food problem. It has been estimated that based upon modest increase in population, by the end of this century we will be requiring about 400 million hectares of land to produce 250 million tons of food using traditional methods of farming as currently practised by the Indian farmer. With the greatest difficulty we can apparently increase our cultivated land to about half that extent. This essentially means some type of energy intensive agricultural techniques will have to be used by the Indian farmers. In the traditional form of agriculture practised by the Indian farmer, for every calory of energy put into the land, it returns five calories of energy by way of food. On the other hand, in the energy intensive form of agriculture practised in the United States, apparently for every 25 calories of energy put into the land, only 5 calories appear in the form of food. However, for this type of agriculture, it has been estimated that only a fourth of the land is required. This form of agriculture has however the disadvantage that manpower is replaced extensively by machine power. The result is that while adequate food is produced, there will not be enough people with money to buy the food ! Clearly direct adaptation of

such farming techniques have no relevance to the Indian scene. They must be suitably adapted so that while modern scientific methods are being introduced, they would not widen the gap between the rich and the poor. One may also in passing recall the note of caution sounded by the Prime Minister recently. Gobar gas plants have been suggested as perhaps one of the significant appropriate technology tools developed to assist the villages. In order to keep them operative, people have been using cowdung collected from the streets also. To that extent, that much less non-commercial fuel is available to the Indian villager. To that extent, the villager will cut more number of trees from nearby to satisfy his energy requirements. This in turn is likely to cause problems of soil erosion. Gobar gas plants, instead of becoming a useful tool to the villager end up as captive alternative power sources to the rich farmer or as a curio to the city dweller. We may recall that about a couple of decades ago with great fanfare we introduced solar cookers. Hardly any remain and it was amusing to see them advertised in shops in the Fifth Avenue in New York. Therefore, one should interfere with age old habits with the greatest of circumspection! It is not that gobar gas plants have no role to play in assisting the Indian villages. It is perhaps the simplest technological device conceived to help the villages to conserve resources and use them effectively. If care is not exercised in its mode of operation, while we may succeed in obtaining a somewhat better utilisation of the cowdung produced daily, we may end up destroying through erosion top soil which nature has taken several hundreds if not thousands of years to build up! In passing it may be noted that there are other alternative feed stocks for gobar gas plants. The much maligned water-hyacinth which clogs our ponds grows at fantastic rates. Its rate of growth in domestic sewage has been shown to be about 17·8 tonnes per hectare

per day*. Recent work carried out in U. K. indicates that it purifies polluted waters to a significant extent and it can be used in gobar gas plants as feedstock. One can thus use the solar energy through photosynthesis to fix carbon and use it in turn to produce methane in the gobar gas plants instead of denying the people who depend upon cowdung collected from streets as a form of energy.

21. The technologies that have been proved valid elsewhere are not necessarily relevant to India which is attempting to close the gap that separates the rich from the poor. In most instances modern technology by its very nature tends to widen the gap. They are not extensions of the traditional skills of our people. Their adaptation almost invariably destroys the ancient skills of a country. It tends towards urban concentration of population with the accompanying residential hells on earth by way of industrial slums. These inevitably lead to the alienation of the young from the old and acceptance of ways of life which have not much to commend them. Man becomes an extension of the machine instead of being the master of his soul and his own craft.

22. If this alienation is not to occur, one has to plan to introduce appropriate technologies. To the extent we are backward, it is not the easiest thing in the world to find appropriate technologies in the developed countries which will satisfy our requirements. There is also the danger that in the name of apıdopriateness, other nations may and will saddle us with obsolete technologies. We had also in the past committed the terrible blunder in many instances of not having established an adequate base for inhouse research, design and development in those industries based upon imported technologies. The result has been, that they did not take root in

New Scientist, 12th August 1976, p. 319.

the Indian soil, and as such, did not enable us to produce the next generation products purely indigenously. We limp from licensed production to licensed production. Instead of becoming tools for technological leap frogging, they have become painful crutches of continued dependence.

23. We thus face the dilemma of establishing on a massive scale appropriate technologies which are not capital intensive; can create large employment opportunities and do not require quantum changes in skills. On the other hand, in our efforts to become a developed nation with control over our destinies, we face the necessity of introducing sophisticated technologies which are highly science based and indigenisation of which require high levels of scientific and technological training. It is also a fact that the level at which we can meaningfully absorb an imported technology or even bargain for it, depends upon the thoroughness of our comprehension of that technology.

24. The gap between the two levels of technologies may never be closed. In fact, it is neither possible nor feasible to do so. But there is place for both. We have to embrace both ends of the technology spectrum. It is an anomalous situation that in these circumstances, our highly trained scientists from institutions of higher learning are migrating abroad. It has been said that this is not much of a loss since they are repatriating substantial amounts of foreign exchange. But I wonder if the equation can be balanced so easily as that! Can one put a price on a Khorana or a Chandrasekhar? What would have been our atomic energy programme had Bhabha decided to settle down in U.K. after he finished his studies? The purpose of higher education is to make one proficient in the methodology of science so that it can be applied to pursue knowledge or solve problems

of technology relevant to a nation. It better to create conditions whereby our highly trained people can stay in the country so that while they work in forefront of science or technology they can assist in the development of more mundane things.

25. Indian scientific and technological scene is thus at the cross roads. It is clear that if we wish to improve the lot of the majority of our people as we must, the technologies to be introduced cannot be too sophisticated and must be easily absorbable. If we want to become a developed nation, as undoubtedly we desire to, we have also no alternative but to concentrate on a few selected areas of high science and high teehnology. For both these, the cultivation of the culture of science, scientific temper and application of the scientific methodology to solve our problems are essential. Scientific progress is above all, due to a non-conformist attitude. While a society depends on conformity for its stability it has to depend upon non-conformity for its growth. To the extent that science is non-conformistic, there is an obligation on the part of the society to nurture science so that out of its activity, society can grow and prosper.

26. It does not seem, so to say, necessary to take science as such to people. But we can certainly take the benefits of science to people. The language of science has become so specialised that it will be an exercise in futility to try to explain it to all. The Indian farmer does not have to know the intricacies of plant physiology to appreciate the importance of fertilisers and pesticides for his crops. He does not have to know how the Transister radio or satellite television work to appreciate the programmes and be benefited by them. His counterparts elsewhere in the developed world are no differently placed and their understanding of

science and technology is basically no different except that modern communications make them better informed.

27. Culture of science and the cultivation of scientific temper in the Indian context will have to be purposefully oriented so that the limited resources we have can be more efficiently deployed. In order that science is used purposefully, as Alvin M. Weinberg* has stated, the cost of applied science will have to be treated as the overhead charges on the tasks it seeks to further; the cost of mission oriented basic science to be the overhead charge on mission oriented applied science. Purest science will have to be considered as an overhead on the entire technological system.

28. While doing all this, and hopefully while making science and technology tools for national economic transformation, one would hope that mindless superstitions and rituals will be swept away and we will be left with values which we all cherish and which have stood the test of time over several millennia. If these too are swept away, it will be a hollow victory for science and technology.

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* Criteria for Scientific Choice 11, Alvin M. Weinberg, Minerva 111 Autumn 1964.

Science and Superstition

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When the innocent looking Vice-Chancellor of the Bangalore University–the Vice–Chancellor without Vice—suggested that I speak on Science and Superstition, I much hesitated and much debated. I know little of science : I know much less of superstition. When this beautiful city of Bangalore is fast developing new supersciences like Sai–ence and Saicharitry, where eminent scientists from higher institutes of learning are talking about miracles, supermen and supernatural, who am I and how dare I, speak about Science and Superstition – particularly so when the Indian scientific community and learned academies have been so discreetly silent about it ?

When mystery men and miracle workers are making their presence increasingly felt ; when from thin air masterpieces of modern technology are credited to be created ; when some claim the power of foretelling the future and others, the ability to forestall it, as a student of science, I must confess I am clearly confused and concerned.

So I began to educate myself reading a number of books on superstition–as many as thirteen books (Superstitions 13 !). Little did I realize that there is such a vast literature in English about superstition, though I could only trace two books in English about Indian superstitions.

The opinions expressed herein are those of the author and do not necessarily reflect that of the organisations he belongs.

The more I read the more I stand confused. I am not sure whether it has done me any good either.

What is Superstition ?

Dictionary definitions are : credulity regarding the supernatural : irrational fear of the unknown ; a practice, ritual or belief based on mysterious and misdirected reverence ; an unreasoning awe or fear of the unknown tenet, practice ; belief or opinion founded on fear or ignorance with no apparently rational basis ; Andhaviswas – blindly accepted belief or practice, an irrational religious belief or practice. Notice the combination of irrationality and religion. The trouble is that one man's religion is another man's superstition.

Apparently, superstition survives on fear, blind belief, unreasoning and irrational attitude.

What is Science ?

Science is knowledge—an organised, systematic formulated knowledge based on observation, experimentation and induction.

The essence of science is scientific method. No pronouncement, however, sacred or high in authority, is accepted without experimental test or proof. Science has a built-in method for correcting its own mistakes. Science is both perceptive and deductive and thus has an element of creation and distruction. Scientific temper is an attitude of mind, an open rational mind, questioning curious critical mind–a tomorrow's mind instead of yesterday's mind–resistant to rigidity and resilient to change.

The distinction between science and superstition becomes increasingly clear. Science evolves, develops in a continuous

correcting fashion and not subdued by the status or symbols of authority of fear of the unknown.

Classification of Superstitions

Superstitions are found all over the world in all walks of life concerning all activities, throughout history. Superstitions may be classified as connected with (a) religion, (b) tradition, (c) function or profession, and (d) purely personal.

Eric Maple describes several superstitions connected with house and garden ; works and travel ; recreation and entertainment, rituals, body and clothes, folk-lore and magic, peasantry and people ; psychic powers, etc. Khannas classifies the Indian superstitions concerning mother and child ; pregnancy and delivery : disease and death : hygiene and health ; travel and pilgrimage ; omens, good and bad : sleep and thought transference, nature and natural phenomena, etc. Bijalwan, the latest book 1976, describes Hindu omens based on SHAKUNAUTI and Shakuna Shastra, like throbbing of limbs, sneezing, playing dice, etc.

Why Superstition

Jahoda, in his book on "Psychology of Superstition", deals with many psychological aspects of superstition. The reasons are critically discussed by Maple. An attempt to explain away three hundred Indian superstitions is made by Khannas.

Superstition is steeped in simple fear – fear of the unknown – in birth, death, disease, danger, despair, distress, doubt, anxiety, uncertainty, stress and strain.

Superstition is the acceptance of superior unknown power which can be made to submit to human will ; to control, or

to offset the unknown evil. It is a protective barrier against a sense of helplessness. Where chances and circumstances are not fully controlled by his knowledge, man turns to magic and superstition.

Superstition is a mode of thinking - a part and parcel of mental make up ; liable to come to the surface under certain circumstances ; superstition stems from an emotional attitude. Language, folk - lore, tradition, religion —all combine and shape the growing mind into a common mould favouring a persistence of superstition.

Superstition is also the result of 'conditioning of the mind' by the hostile environment and tradition 'speak of the devil—he is sure to appear' !

Superstitions being the idiom of the people, are taken with the mother's milk so to speak and become integrated with the language of thought. Superstition is the name of the game by which mankind seeks to protect itself— from the enemy of survival.

Superstition is also closely connected with the childlike curiosity of human mind—noticing the mystery of nature ; looking at life with awe and wonder--trying to interpret the unusual happenings around man : to find order in disorder : 'one in many'– unity in diversity : interpreting coincidences and correlations. Instinctively man sees meanings in the unusual things happening–which are more intuitive than rational, *e.g.* a neem and pupil tree grown together ; crystal clear water coming from a hill.

Some superstitions are designed to educate people about health and hygiene ; safety, security and stability, economic new necessities, *e g.*, a sacred cow and finally become a way of life. As time passes by the reason behind is forgotten and the shell remains.

'Superstitious man believes in what he *wants* to believe or what he *needs* to believe.'

When emotion and fear get in, reason and confidence get out resulting in superstition giving an imaginary control over hostile environment. Superstition in essence is a kind of insurance against hell and then hesitating to pay the premium.

Science-Superstition-Spectrum (SSS)

Now let us look at science and superstition closely.

Science or superstition is basically an attitude of mind–one rational, the other emotional and irrational. Observation. in little known fields are difficult to interpret. Here comes the difference. Superstition goes by personal blind beliefs and revelations. Whereas science goes by experimentation and suspending judgement unless the evidence tips the balances Superstition is a relative concept dependent on the state of scientific knowledge at a particular point of time.

Do you also notice now the close relationship between ritual part of religion and superstition as contrasted to science. Both science and religion are seekers of truth : make one feel humble ; both act on faith (religion on blind faith) : both act as a cementing substance between people and both set a code of conduct. On the other hand, the ritual part of religion is more close to superstition.

Surely, science and superstition coexist but are not complementary. Scientific knowledge is a rational process in which dogma, rigidity, revelation, ritual, mystic belief and miracles have no place.

This science-superstition-spectrum has thus at one end the scientific society evolved by socialist systems where scientific attitudes rule supreme and at the other extreme, the mass of humanity where superstition and dogma are the principal deities.

Juxtaposed between these two is a developing nation like ours where the new and the old, science and superstition coexist and continue to affect the lives of our people. This sort of an amalgam is nothing peculiar to us. It has been there in the West. And the course of science, like that of love, never runs smooth. Superstition has often been the speed-breaker of science. Historians and sociologists of science have tried to find answers why this has been so. Merton in his 'Science, Technology and Society in the Seventeenth Century England' conceived of science 'as a cultural artefact, a manifestation of intellectual energy that is stimulated, checked or modified by the structure, beliefs and aspirations of the society with which this scientific activitiy is associated.' He concluded that the scientist's choice of problem was much influenced by socio-economic considerations.

Even highly educated people in our country are known to wait for the auspicious hour, day or the week in order to start an activity. The belief in rahu kalam and yamagandam (inauspicious hour) is commonplace.

Superstition has it that the eclipses are caused by the demons Rahu and Ketu devouring the sun or moon. Much after man has landed on the moon, our people–not a few of them professing to be scientists–give a lot of weightage to horoscopes. To cap it all, if found 'wanting' from the viewpoint of celestial combinations, people are advised to perform religious ceremonies to ward off evils.

Belief in life after death is not uncommon. As Julian Huxley puts it, "belief in a supernatural after-life leads to concentration on attaining salvation in the other world and to a lack of concern for life in this world and its possible improvement." Also, "belief in supernaturalism and the miraculous and magical elements which go with it always

leads to gross superstition, and, usually, to its financial exploitation".

This is the crux of the problem. When millions are dying of hunger in one part of the country, large quantities of food-stuff (ghee particularly) are known to be consigned to flames in the name of a yagna. All because some wise men have thought it fit to exploit people in the name of religion. If mantras can give much wanted food, the world will be an easier place to live. Incidentally how is it, yagnas are performed to get rain only in the rainy season !

Superstition leads to roaring trade and even new technologies are developed to bolster superstitions. Factories have been set up for the express manufacture of witchcraft equipment, talisman, etc., if only to maintain the old castles, reportedly haunted by whispering ghosts. Planchettes, electromagnetic belts, organe energy boxes, divining rods, talisman, amulets, birth stones, lucky charms form a big import-export trade : Predictions and periodic forecasts find a prominent place in most periodicals. The computer horoscope is a multi-million dollar enterprise in U.S.A. Astrology as a science is taught in colleges. The fact that as many as 168 leading scientists of the world including 18 Nobel Laureates launched an outspoken attack on astrology is a proof of the magnitude of the problem.

Some superstitions are positively harmful, *e.g.*, misplaced beliefs in the possibility of doubling money ; of transmutation of metals, or getting male offspring by human sacrifice, etc., often lead to tragedies.

The greatest damage done by superstition is that they deflect attention from the primary cause and lead to a defeatist attitude of helpless acceptance. They stand in the

way of unearthing the root cause and undertaking adequate remedial steps.

The rate of growth of superstition is directly proportional to the gullibility of a people not alive to what science is and what science would do to enrich their lives. In a situation like this the combination of the two, *viz.*, belief in supernaturalism and in Absolutes 'constitutes a grave brake on human advance, and, by obfuscating all the major problems of existence, prevents the attainment of a full and comprehensive vision of human destiny.' However, it is known that science has been encroaching upon and diminishing the domain of superstition. But more of that later.

Science behind Superstition

There have been numerous attempts to find scientific basis for superstitions, *e.g.*, astrology, palmistry, nadi shastra; the shelf life of Ganges water ; the application of tilak or vibhuti on the forehead, the beneficial effects of transcendental meditation, etc.

Some of the explanations appear to be counter-productive. Tromb argues that planets and stars influence earth's electromagnetic fields which in turn mould a person's character and future. He however thinks astrologers made a grave mistake in using the date of birth instead of the date of conception. This leads us *to Pseudo-Science.*

The curious consequence of the boom in science is the growth of dubious sciences like 'dianetics', extrasensory perception (ESP), psychokenesis (PK), clairvoyance, etc. As early as 1927, David Starr Jordan, first President of Stanford, wrote a fascinating book called "The Higher Foolishness", and coined the words 'Sciosophy' meaning 'shadow wisdom' to stand for 'systematised ignorance' of

pseudo-scientists: Martin Gardner in his interesting book on 'In the Name of Science (1952)' brings out the unbelievable amount of intellectual energy that has been wasted on the lost causes and the grotesque extremes to which deluded scientists can be misled and in turn mislead others.

Standen in his book 'Science is a Sacred Cow' has a swipe at scientism. Gillets' 'Bumping' theory looks at Einstein's relativity as "a moronic brain child of mental colic". Sir Isac Babson's Gravity Research Foundation has been the most useless scientific project: Seldom before a crackpot like Lysenko received so much attention and power.

Belief in psychic phenomenon and parapsychology is as old as humanity. However, it is only of late, attempts are made to give it a scientific bias, and tested in laboratories by reputed scientists.

In his books and articles, the reputed psychologist Dr. Joseph Banks Ryne claims that ESP including telepathy and clairvoyance have been demonstrated beyond doubt by millions of people. However, only firm believers in ESP confirm his findings and not by doubting psychologists. The same is said about miracle men in India. This is it: Believe blindly, only then miracles can work! Even our scientists tell us that such men and such powers are 'inexplicable' and 'inscrutable'. As Abbas puts it — "inexplicable cannot be described in rational terms and inscrutable can't be subject to scrutiny by enquiry or reason — It is accordingly outside the realm of rational analysis. That settles the argument.

Similarly, in a fascinating volume, D. H. Rawcliffe holds up to the stern light of rational examination, hundreds of most persistent illusions and delusions of mankind like crystal gazing, automatic writing, table-turning, stigmata bycanthropy, mediumistic trances, drowsing, telepathy, ESP, PK, etc.

The most apparently convincing evidence for supernatural and occult phenomena vanishes into an insubstantial tissue of trickery and delusion whenever it is closely examined.

In this field of psychic phenomenon, there appears to be two extremes in regard to scientific theories and the scientific competence of the experimentors from fully proved to totally false and in between several grey areas existing.

In spite of far from conclusive quality of the evidence, some of the intelligentsia like H. G. Wells, Upton Sinclair, Aldous Huxley, Jules Romains, Arthur Koestler, etc., have accepted E.S.P. Max Freedom Long in his book, 'Science Behind Miracles' (1948) speaks about the mind's vital force over matter: *e.g.*, talking to the trees to help them grow taller! Do you remember the experiments at Annamalai University not long ago, claiming music and dancing helping the plant growth?

Arthur Koestler and Rosalind Heywood in recent issues of 'Sunday' have discussed the four categories of ESP, *viz.*, precognition, retrocognition, clairvoyance (reaction to physical events) and telepathy (reaction to another person's mental state) and the sparks of consciousness that seem to exist outside the physical world. They assert dualism exists in religion and science: the 'one' and 'many'; the conscious and the unconscious: reason versus passion; mind versus intuition; the feminine, the sacred, the mysterious against the masculine, the profane and the logical; the man's split mind with belief and disbelief, etc.

The pathology and creativity and the split between reason and emotion–Schizophysiology–are said to be the two sides of the same medal, coined by the same mint master. The 'thinking cap' governs rational thought and the archaic structure of the brain is said to govern emotional reactions.

The electron is at the same time corpuscle and a wave and this dualism is fundamental to the physics and known as the principle of complementarity.

This principle of complementarity and dualism, according to these writers, may be applied to science and spirituality, socialism and spiritualism : body and mind ; modern science and para-science ; psychology and para-psychology : and physics and metaphysics, etc.

Koestler himself admits the wings of analogy are notoriously treacherous ; metaphors and parables do not make proofs ! Aristotle wrote "that it was probable, the improbable would sometime takes place". As Charles Chan once expressed it. "Strange events permit themselves the luxury of occurring."

Let it be freely admitted, however, that science is not in a position to interpret rationally several facts of life. For example, the mathematics of Ramanujam ; Shakuntala's faster than computer mind for mathematical calculations, etc. "Science" in the words of Tagore, "is an endless striving, stretching out the hands towards perfection."

Similarly the greatest myth of scientific age is that scientists are not superstitious ! Gardner in his recent article in *Science Today* (Sept. 1976), tells us, how scientists are the easiest persons to fool in the world. 'No ox so dumb as orthodox ox'. Most people assume that a man with brilliant mind is qualified to detect fraud. This is untrue. Unless the mind is thoroughly trained in the underground art of magic, it is easier to deceive than a child.

In India, we have our own versions of these pseudo-sciences and scientists. If one tries to list the various forms of superstition existing in this country, one will find the task

formidable. Judged by the space it occupies in the weekly press particularly of late, obviously, millions of people mill around miracle men, mind readers, astrologers, palmists and others that practise dubious arts flaunting them as God-given gifts.

Indian scientists are no exception. The majority are ambivalent–a scientist in the laboratory a superstitious addict at home. The medical doctors wear amulets ; the scientists break coconuts to bribe the gods to succeed in their efforts. In the sea of tradition-bound society, steeped in superstition, science gets encapsulated without much interaction and progress is blocked.

The question now arises—how do we envisage that science and scientific attitude can counter the effects of superstition in a society ?

Can Superstition survive ?

The worst of the superstitious is that they are easy to make and hard to destroy.

Apart from giving an unreliable sense of security for the anxious people, does superstition serve any useful purpose ? It is a big question !

If there is no struggle for survival, no fear of death, doubt, uncertainty, is there a need for superstition ? Would man be superstitious, if he can govern his circumstances ?

Some are firmly convinced of the efficacy of their private rituals : Some scoff at superstition and most people are somewhere in between these two attitudes. Some are apt to be shamefaced about superstition ; deny in the public but practise privately. Some follow the rituals and superstitious beliefs, to respect the elders : Some practise superstition with

the belief that "for every evil under the sun, there is a remedy, or there is none : if there be one, try and find out : if there be none, never mind it." (W.C. Hazlitt : *English Proverb.*) 'Why start with doubts, we might as well go through with them' is yet another attitude. The sheepishness or group behaviour, not daring to be different is yet another cause to carry on with superstitions.

Today there exists two schools of thought. One school believes that constant advances in science will conquer superstition. Science is like spreading water on a dusty floor: as the water spreads, islands of dust remain but eventually close up. Others see superstition as a way of life—an example of shortcomings of human mental process. As with the advance of medicine itself has produced a new crop of diseases, scientific advances bring about new kinds of superstitions. But again, it is for doctors to fight against disease with new knowledge and so also for educators to wean away people from the harmful superstitions.

Man - a Mixture

Man is rational and irrational : A man is different from the other man and how different, it is difficult to determine, for the lack of suitable tools and techniques. Man has mind and body giving creative and productive capacity. Science is the tool to reduce the irrational and increase the rational attitudes : to maximize the returns from his resources and to change his life styles. Scientific process is the liberation of fman from irrational attitudes and free him from their interference with his production processes.

Science affects skills, attitudes and behavioural patterns to which tradition and superstition offer resistance. A strategy has to be evolved for weakening the forces impeding

this change and strengthening those that favour it. Through popularisation of science, the curious, critical, questioning, sceptical and scientific attitude and rational outlook should become a way of life breaking away from the stranglehold of superstition, rituals and taboos of traditional society.

Education is intended to foster the ability of objective judgement. It is this liberal education and lingering past which determine the extent of rationalism in our lives.

Much of our science education today, at high school and even college levels is reduced to magic in the absence of facilities for experimentation. The time has come to bring science to the doors of the common people through planned experiments and practical demonstrations. For example, seeing is believing. In the long run only the correct education will provide the necessary condition.

Early historians gave first place to ancient Indians in the development of science and scientific attitudes. Imagine *Vishnu Purana* mentioning about one day of the Creator Brahma is equal to 4320 million years which is so remarkably close to the present day calculations. But where has it all gone and why has this rich tradition of science decayed? Is it because of the over emphasis of superstition, narrow outlook and rigid rituals?

Let us take a look at the origin of modern science.

Modern science in India developed under protection and patronage of the British and as an extension of British science. Consequently, it never acquired the necessary revolutionary character as in the West, in the terms of challenging the prevalent outlooks and intellectual attitudes and values generated by them. Science had to fight its battle in the West, quite often in the open, as in the case of Copernican and Darwinian theories. In this conflict, spread over a long

period, science emerged always victorious and established a climate of opinion based on its methods, techniques and achievements which advocated new value systems and ideals.

Science in India did not go through this process. It developed as a mere academic discipline. Prof. Bernal summed up the situation thus: "It is inevitable that in science as in other aspects of life the Indian should feel the need for national self-assertion, but this attitude is always an uneasy one. The Indian scientist must, in the first place, learn this science through English channels and be subjected to the patronizing and insulting habits of the English to their subject races. The reaction to this breeds a mixture of submissiveness and arrogance that between them inevitably affect quality of the scientific work. Indian science is noted at the same time for the originality of many of its conceptions and experimental processes, and for extreme unreliability and lack of critical faculty in carrying out the work itself." In addition it created on those who took to the study of science a peculiar ambivalence — of being scientists in the laboratory and addicts of anti-scientific attitudes, believing in ritualism, social prejudices and other common beliefs at home.

One would have expected that after India achieved her independence there would be a radical change in the attitude of people to science and that scientific temper would come into being, particularly in view of the policies adopted by the Government. The policies helped in the increase in number of institutions, scientists and expenditure on science but did not generate a scientific movement.

The reason is not far to seek. There has been a lack of confrontation between scientific knowledge and religious views not on philosophical issues but on socio-religious-ritual-superstitious attitudes. That this confrontation has

not taken place may be due to the ambivalent attitude of Indian scientists themselves.

But the picture is now changing.

Today, more than ever, the scientific attitude, scientific temper and the spirit of science are catching on. One finds open discussions and debates are taking place on the question of blind beliefs and superstition. Government are also seized of the importance of effecting radical changes in the social structure of the country by the application of science and technology. The Prime Minister of India has been repeatedly urging the Indian scientists 'to strike beyond the narrow ritual of restricting rational thinking to laboratories and lecture halls.

There are three noticeable steps initiated to fight superstition and inculcate the scientific attitude among the masses.

First, the 'catch'em young' policy of introducing science as a compulsory subject in the schools. Secondly, the emphasis given to the development of rural technology and through it involve the rural folk in the application of science and technology to their problems. In this process of 'taking science to the doorsteps of the villagers' superstitions and ideas of mysticism are sought to be effectively subjugated, a rational approach is introduced and the rural people are imbibed with a spirit of inquiry and reform. Thirdly a major step has been taken in incorporating the clause about scientific temper in the revised constitution. One of the fundamental duties under 51 (A) (h) is to develop the scientific temper; humanism and the spirit of inquiry and reform.

This is a precursor and an earnest endeavour of the Government to the use of science and technology in the

achievement of a welfare state. Such problems as health, family planning, social reforms, etc., where there is prevalence of widespread superstitions and irrational fears have to be tackled in a scientific manner and this can be done only by making the common man think rationally. In the words of Mrs. Gandhi, "We want scientific thinking to destroy superstition which has darkened our lives ; to light the spark of adventure and bestow the gift of far-seeing wisdom and scientific attitude."

In this national task, the Indian scientist has his role. He has to face the challenge and make a determined effort to replace antiquated ideas, prejudices and superstitions with knowledge based on rational thinking. But in so doing he should not expect miracles, as science and miracles do not go together. The process is bound to be slow and he should understand the delicate mechanism that controls this pluralistic society. In this, one cannot but agree with our Prime Minister. I quote, "I think men of goodwill, men and women who are interested in science will try to enlarge the areas of light and try to fight darkness. We have in India to adopt not only scientific methods but a more rational thinking and by this I do not mean that we should sweep overboard other values which we have but merely that those values should be used to help us to enjoy a better life and to make most of it."

That, then, is the way for science to meet superstition and other such irrational phenomena.

Science and Agriculture

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About 10 years ago, some foreign experts believed that India could never become self-sufficient in its food requirements. They predicted the outbreak of widespread famine and hunger in India on the basis of theoretical calculations of the year when the food needs of the poor nations would exceed the capacity of the rich nations to meet them. Paul and William Paddock, for example, fixed this year as 1975. Some others felt that such a contingency would arise only in 1985. Our failure to achieve during the nineteen fiftees and early sixties the anticipated results with the Community Development and the Intensive Agricultural District Programmes fanned the sentiments of the pessimists. It was widely believed that in our rural areas developmental action and achievement were being impeded by the limited sights of our farming community. Experts wondered why we should find it so difficult to become self-reliant in our food needs, when there appeared to exist several easy pathways of the control of rats to wipe out the deficit in our food budget, while the agronomist would plead for using good seeds and some fertiliser for achieving the same end. The fact remained, however, that progress in improving production was slow and largely took place through an increase in the cropped and irrigated area, rather than through any appreciable increase in productivity.

The economic plight of the small farmer remained unchanged since his real income would rise only if productivity was improved and marketing organised so that the small producer got a fair share of the price paid by the consumer for a commodity. While Government was anxious to push up agricultural production and Jawaharlal Nehru gave expression to this desire by his oft-quoted statement, "Everything else can wait but not agriculture", there was despair during the drought years of the mid-sixties concerning our agricultural destiny.

Famines and scarcities

Historically, famines and scarcities have been known in our country from the earliest times. They are mentioned in Mahabharat and there is a Jain legend of a 12-year famine in the fourth century A.D. It is recorded by the official historian in the Badshah-Namah that in the famine of 1630-32, the Emperor Shah Jahan opened soup kitchens, gave a lac and a half to charity and remitted one-eleventh of the land revenue in the affected area. Subsequently, there have been numerous famines but it was only during the famine of 1868-69 that it was clearly stated that "the object of Government was to save every life". The birth of agricultural departments in our States and of Famine Codes took place as a result of the recommendations of the Famine Commission of 1878. The Scarcity Manuals currently used by several State Governments are largely based on the Famine Codes of the last century.

Meanwhile a silent revolution has taken place in the minds of our farming community as a result of the new production technologies introduced through the High-Yielding Varieties Programmes, Intensive Cotton District Programme including hybrid cotton which was introduced into commercial cultivation for the first time in the world and the Cattle

Cross-breeding projects. Obsession with destructive criticism has blinded us to the meaning and implications of the increase in wheat production from a little over 12 million tonnes to over 27 million tonnes in just six crop seasons beginning from 1967-68. There has not been much interest in studying how a small Government programme in wheat was converted into a mass movement by our farmers It is not only in the Punjab or Haryana that wheat production went up dramatically but also in non-traditional wheat areas like West Bengal. While in the past it was difficult to induce farmers to take to a rat control operation, farmers took pains, in the wheat belt, to see that rats did not migrate from sugarcane fields to wheat. While in the past everyone knew that farmers were sitting over a large underground water resource in the Indo-Gangetic plains, it was only the introduction of high-yielding varieties of wheat and rice that provided the necessary motivation for them to take to the construction of tube wells—whether made of metal or of bamboo—on a large scale. The truth of the saying "Necessity is the mother of invention" was proved to be true in the case of wheat cultivation, where farmers somehow managed to produce or get the seeds they needed, the diesel pumps if electricity was not available and get the requisite number of threshers and other implements as well as storage bins fabricated in record time. That our farmers may not wait for research workers to produce perfect tools but will themselves innovate and find a solution to a pressing need was shown by the Bihar farmer, Shri Ram Prasad Chaudhary Jaiswal of the village Lalpur who first put up a bamboo tube well in the Saharsa district. Farmers who learnt the economic value of good management in wheat also took to better practices in rice, potato and other crops, with the result that agriculture as a whole started moving forward in such areas. The sudden and steep spurt in fertiliser demand is an eloquent testimony to the credibility of the new varieties and techniques.

The concept that agricultural advance in India would suffer due to the limited vision of the farming community was thus disproved. The social tensions between those who had access to the inputs needed for adopting the new technology and those who did not have similar access, only underlined the fact that those who have notd erived economic benefit from such technology are equally anxious to take to the technology. The desire to change farming methods thus fanned both joy and sorrow in our countryside. This in turn generated considerable thinking and action on the part of Government. resulting in programmes for marginal and small farmers. expansion of credit facilities and more recently in integrated farmers' service societies on the lines recommended by the National Commission on Agriculture.

Assets

Sunlight, soil, water, plants, animals and human beings constitute the basic resources of our agriculture. Fortunately, sunlight is abundant except during limited periods in the monsoon season and generally does not constitute a limiting factor in production. In arid and semi-arid areas, the intensity of solar energy is fairly high and exceeds 650 cal/cm^2/day. Under such conditions evapo-transpiration rates become high. The average annual values of energies available in peninsular and North India are 473 and 460 cal/cm^2/day respectively. Apart from the use of sunlight by plants in the process of photosynthesis, solar energy is used in rural areas for purposes like drying of crops and grains, distillation, evaporation for salt production and heating. There is, however, considerable scope for improving the use of sunlight both by plants, through multiple cropping, and by converting solar energy into thermal energy.

Out of our total geographical area of 328·05 million hectares, the net area sown during 1969-70 was about 139 million hectares. Forests occupied about 65 million hectares and uncultivated land was about 101 million hectares. Thus, the net sown area under crops in 1969-70 was 45·5% of the reporting area and the area under forests was 21·3%. The net national product was Rs. 34,253 crores during 1970-71 at current prices and Rs. 18,876 crores at constant 1960-61 prices. At 1960-61 prices, the contribution of agriculture, forestry and fishing to net national product in 1970-71 was 44·4%. The contribution of agricultural products to the total export earning in the same year was 37·1%.

Diversity in physiography

The physiography of our country shows great diversity. On the one hand, we have major mountain ranges with the Himalayas, at once one of the youngest as well as the mightiest of the world's mountain systems, in the north and the Aravallis, the Vindhyas, the Satpuras, the Eastern and Western Ghats and the North-eastern ranges including the Garo, Khasi and Jaintia hills in the other parts of the country. Plateaus, ranging in elevation from 300 to 900 metres, constitute a prominent feature of our topography, the well-known among them being the Malwa, the Vindhya, the Chhota-Nagpur, the Satpura, the Deccan, Ladakh and Meghalaya. A very large part of the country consists of extensive plains watered by great rivers where a considerable portion of humanity live. In the rivers originating from the Himalayas, the dry weather flow is generally good due to water coming from melting snows and glaciers. The lean period for these rivers is the winter months but at no time is the flow so reduced as in the peninsular rivers. The flow in the rivers of peninsular India undulates heavily, with big

discharges during the monsoons followed by low discharges during the rainless months. Variations of the order of 1 to 300 in the mean monthly flows of these rivers are common.

Our climate shows equally great diversity, ranging from continental to oceanic, from extremes of heat to extremes of cold, from extreme aridity and negligible rainfall to excessive humidity and torrential rainfall. The Himalayas present a barrier to the influence of cold winds from Central Asia and give the sub-continent the elements of a tropical type of climate. The variations in rainfall, temperature and humidity caused by the incursion of comparatively cool currents from the Indian Ocean across the Bay of Bengal and the Arabian Sea and by the movement of shallow depressions, which originate outside India, to the west, lead to extremely complex weather patterns, which prevail even over those areas which can be grouped climatologically under a single type. Thus, temperature, rainfall and the amount of vapour in the air, which influence greatly the growth of crops, show wide variations even within small areas.

An interesting feature of wind system over the Indian Ocean and the adjoining sea and land areas is the seasonal reversal of the monsoon. During the late summer, the winds flow from the south-west over the sea towards India and Burma, while during the winter the flow of currents is from India and Burma over the Bay of Bengal and the Arabian sea towards the Equator. The south-west monsoon season is responsible for over 80 per cent of the total rainfall in most parts of the country.

On an average, we receive an annual rainfall of about 370 million hectare metres. It has been estimated that about 80 million hectare metres seep into the soil of which about 43 million hectare metres remain in the top layers and

contribute to soil moisture which supports crop growth. The ground water recharge available for utilisation may be of the order of 26·75 million hectare metres, while the current utilisation is about 10 million hectare metres. As a result of the various major, medium and minor irrigation projects undertaken, the area under irrigation during 1969–70 was 30·3 million hectares. The Second Irrigation Commission has calculated that the ultimate potential for irrigation from conventional sources is 81·7 million hectares. It is premature to guess what the contribution of weather modification and desalination will be in the future to augment water availability in drought-prone areas. The states which have less than 15% of the net cultivated area with irrigation facilities are Mysore, Madhya Pradesh, Maharashtra, Gujarat and Rajasthan. Much of the knowledge we have on ground water resources is confined to the alluvial and semi-consolidated areas, whereas 70 per cent of the total geographical area of the country is covered by hard rock.

The geo-hydrological studies carried out by the Geological Survey of India as well as the studies carried out under the auspices of the Central Ground Water Board have revealed great opportunities for scientific ground water exploitation. Fresh ground water has been found in the heart of the great Indian desert near Jaisalmer, in the Narmada and Purna Valleys, the Rajamundry and Tirupati sandstone areas of Andhra Pradesh and the Cuddalore sandstone and the Neyveli lignite areas of Tamil Nadu, in addition to the already well known areas of Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal and Assam. Opportunities for lift irrigation from perennial streams and rivulets are also yet to be fully utilised.

With the growth of vegetation and evolution of agriculture, what were once geological deposits got gradually

converted into soils. The topography, biology, physics and chemistry of soils provide an interesting account of past history of that soil. In particular, they indicate the extent of interest taken by man in the care and maintenance of soil fertility and productivity. Examined by such criteria, our record is dismal.

Our major soil groups

We have four major groups of soils—alluvial, black, red and laterite, several other types like forest, desert, alkaline, saline and acidic soils occurring in smaller areas. The red soils occupy 72 million hectares and are found in both high and low rainfall areas. The stored mixture of a saturated red soil profile is generally sufficient to support a standing crop only for 2 to 4 weeks. Hence mostly kharif crops are raised in such soils. Red soils are generally low in nitrogen, low to medium in phosphorus and medium to high in potash. Drainage is not usually a problem in such soils and hence they can be converted into irrigated land without difficulty, if a water source is available.

Black soils which occur in about 64 million hectares are variable in depth and are generally found in regions with an annual rainfall ranging from 500 to 1200 mm. While in the shallow black soils, only kharif crops are grown, rabi crops are raised in the deeper soils with residual moisture. Drainage and erosion are serious problems in such soils and hence there have to be appropriate arrangements for drainage and soil conservation, when such soils are brought under irrigation. Black soils contain 40 to 60 per cent clay and are plastic and sticky when wet and very hard when dry. They contain a high proportion of calcium and organic matter, magnesium carbonate, considerable iron and fairly large quantities of magnesia, alumina and potash. In

black soils derived from ferruginous schists, there is generally a layer rich in nodules of 'kankar' formed by segregation of calcium carbonate at lower depths. The most important difference between the red and the black soil lies in the amount and type of clay mineral present. The montmorillinitic type of clay predominates in the black soil and this imparts the characteristic swelling and shrinking properties of these soils. On the other hand, the non-swelling kaolinitic clay predominates in the red soil. The black soils, also known as 'grumosol', 'regur' and 'black cotton soils', have self-mulching properties, the repeated wetting and drying causing clods to crumble into small aggregates forming a surface mulch. These soils are also referred to as being 'self-swelling', since the surface mulch falls into the deep cracks and thus becomes incorporated into the subsoil. Thus, on the one hand, the black soils have a good capacity for conserving soil moisture, and on the other, they need proper tillage and management to overcome the handicaps of their bad structure.

Alluvial soils occupy an area of about 64 million hactares and are generally deep and variable in structure, ranging from drift sand to loam and from fine silts to stiff clays. The main characteristics of these soils are derived from their having been deposited as silt by the rivers, particularly those of the Indo-Gangetic and the Brahmaputra systems. The physical characteristics and nutrients status of these soils vary considerably. In the south, for example, the Godavari alluvium is rich in lime, phosphates and potash, while the Cauvery alluvium is relatively poor in plant nutrients. In Assam, the old alluvial soils are acidic, while the new alluvium is usually neutral or alkaline. In West Bengal, the old alluvial areas are much less fertile and productive than the new alluvial soils.

Hard pans occur in the soil profile, particularly in the Indo-Gangetic alluvium of Uttar Pradesh, Punjab and Delhi as a result of infiltration of silica or calcareous matter and the presence of 'kankar'. Such hard layers impede root growth and percolation of water In general, alluvial soils are ideal for irrigation and ground water exploitation.

In about 13 million hectares, we have laterite soils, generally associated with undulating topography in regions with annual rainfall ranging from 1200 to 3000 mm. They are essentially composed of a mixture of the hydrated oxides of aluminium and iron with small quantities of manganese oxide and titanium. These soils are poor in lime and magnesium and deficient in nitrogen. Generally, they are poor in available phosphorus and calcium and have a relatively low organic matter content. Such soils are well-developed on the hills of the Deccan, Mysore, Kerala, Tamil Nadu, Madhya Pradesh, Eastern Ghat region, Orissa, Maharashtra and parts of Assam. The high and low level laterites of Tamil Nadu and Kerala are rich in plant nutrients, supporting paddy in the low levels and tea, coffee, rubber and cinchona at the higher levels. The higher the altitude, the more acidic is the soil. There is a good potential for exploiting ground water in many lateritic areas.

In addition to these major groups of soils, we have problem soils suffering from salinity and alkalinity in about 7 million hectares. There are also peaty saline soils called 'kari' soils which are heavy black soils, highly acidic and rich in organic matter. Marshy soils occur in the coastal tracts of Orissa, the Sundarbans and other areas of West Bengal, North Bihar the Almora district of Uttar Pradesh and the south-east coast of Tamil Nadu. Forest soils containing a heavy deposition of organic matter derived from forest

growth and desert soils occurring in parts of Rajasthan, Gujarat and Haryana, constitute the other important groups.

The main rivers of the Indo-Gangetic plain have extensive areas lying adjacent to them known as khadir in western and central Uttar Pradesh, diara in Bihar and eastern U.P. and char in West Bengal. The soils of these areas range from unconsolidated sand to silt and are rich in potash but low in phosphorus. Different management procedures are needed for the sandy, water-logged, saline and good areas of the reverine soils of Bihar, Uttar Pradesh and West Bengal. In U.P. and Bihar alone, such area extends to about 2.4 million hectares and these are potentially high production soils.

We have also rich rock phosphate deposits both in north and south India and phosphorus rich sands on the beaches of Laccadive, Minicoy and related group of islands in the Arabian Sea. Gypsum deposits are available in Rajasthan.

Floristic diversity

Consequent on our varied soil and climatic endowments, we have over 20,000 plant species occurring in our country, a number which is far higher than those found in countries with larger land mass. Such a floristic diversity is obviously the consequence of the prevalence of tropical, sub-tropical, temperate and alpine areas, where the precise flora may vary depending on latitude, altitude, variation in mean annual day and night temperature and the severity of summer and winter. We have over 4,000 woody species of plants and among them about 50 are of major utility. The potential productivity of our forests has been estimated to be of the order of 490 million cubic metre of fuel wood and 8.9 million cubic metre of industrial wood which are, however, extremely low, the gross revenue being only Rs. 21.50 per hectare.

Our wild plant wealth, used in various forms by people in tribal areas, includes about 500 species, mainly belonging to the families Gramineae, Orchidaceas, Papilionaceae, Rubiaceae, Euphorbiaceae, Moraceae, Compositae and Labiatae. If we total up plants under cultivation on some scale, their number comes to about 250, excluding the ornamental trees, shrubs and herbs. It is believed that about 35 of these species might have been first domesticated in India and our neighbouring countries. There is a large genetic variability in our country in crops like rice, sugarcane, mustard, *arboreum* or Asiatic cotton, *tassa* jute, various pulses, vegetables such as brinjal, cucumber, gourd, yam, black pepper, cinnamon, turmeric, mango, banana, citrus, jack fruit, *ber*, *phalsa*, *amla*, and *jamun*. Even in plants introduced from the New World, considerable variability appears to have been generated subsequent to their arrival in India. A few examples are maize, chilli, potato and cucurbits. We have areas in the country like the north-eastern Himalayas which have very rich variability in crops like rice, maize and citrus. A unique type of arboreum cotton with long bolts occurs in the Garo hills. There are trees of mandarin oranges in the Jowai area of Meghalaya which have been productive for over a century. The Jeypore tract of Orissa is also a centre of considerable variability in rice, while in central India, there is vast variability in several pulse crops. It is only recently that serious attempts have been made to domesticate some of the medicinal plants which are otherwise directly collected from the wild state and used.

An example of such a recent domestication is the release for cultivation in the Bangalore area of strains of Dioscorea floribunda, a plant native to central America and which contains Diosgenin, a steroid used in oral contraceptive pills.

Impressive animal wealth

Equally impressive is our animal wealth. According to the livestock census of 1966, our total livestock population was 344 million including 176.0 million cattle and 53 million buffaloes. Both in cows and buffaloes we have an impressive array of hardy and productive breeds. Exotic breeds like Hostein, Brown Swiss and Jersey are being increasingly used in cattle breeding programmes. More than 60 per cent of the total milk production comes from about 23.4 million buffalo cows. The best dairy animals in our country have, however, an average production efficiency of only 25% of their counterparts in Europe and North America.

We have about 4.2 per cent of the world sheep population, numbering according to the 1966 census about 42.0 million. In addition to wool, mutton and milk, sheep contribute at present 15.5 million pieces of skins and 2.1 million tonnes of manure. Sheep abound in semi-arid and arid areas and both the hot desert of Rajasthan and the cold desert of Ladakh offer great scope for sheep and goat improvement. Our poultry population is equally high, having been estimated at 115 million in 1966.

Animals also contribute over 28 million H.P. of energy per day for agricultural operations. Good animals found in states like Punjab, Haryana, Andhra Pradesh and Tamil Nadu may give about 1 H.P. per pair per day of 8 hours, while those in the eastern states may give only half as much. It has been calculated that to produce an yield of 2 tonnes per hectare, the average power requirement would be about 0.75 H.P. per day. The current power availability including those provided by man, animals, tractors and power tillers comes to only 0.30 H.P. per hectare. Thus, inadequacy of power is one of the basic causes for our inability to improve the efficiency of farming through timely agricultural operations.

Marine fisheries

Fisheries, both marine and fresh water, constitute one of our great assets. Over 3 million persons live on marine fisheries and the gross annual revenue to the country from fisheries is over 300 crores of rupees. Our marine fish catch has increased from about 4 lakh tonnes in 1947 to about 1·2 million tonnes in 1971. We are now the second biggest shrimp producing country in the world and the export of seafood during 1972 earned for the country over Rs. 60 crores. The estimated potential catch from the western Indian Ocean is about 8·9 million tonnes consisting of 4·4 million tonnes of pelagic fishes and 4·4 million tonnes of demersal fishes including prawns and other crustaceans. The potential catch from the eastern Indian Ocean is about 5·5 million tonnes of demersal fish. Another index of the untapped marine fish resources we have is provided by comparable figures on catch in different oceans. The yield per sq. km. is about 233 kg. in the Atlantic Ocean and 196 kg. in the Pacific Ocean, in contrast to 37 kg. in the Indian Ocean. Even out of this low yield, we catch very little. For example, the total tuna catch from the Indian Ocean is about 175,000 tonnes, out of which our share is about 5,000 tonnes. The rest is caught mainly by Japanese, Korean and Taiwanese vessels.

Though the current contribution of inland fisheries, including both capture and culture fishes is low and amounts only to about 690,000 tonnes per year, there is vast scope for improvement through modern aquaculture techniques. Water pollution and water weeds could become some of the greatest threats to fish culture and hence deserve serious attention. Domestic and municipal wastes contribute more in many areas to pollution than industrial effluents.

Any account of our agricultural assets will be incomplete without a reference to the excellent network of agricultural universities, research institutes and demonstration-cum-training centres which we fortunately have. A recent analysis at the Yale University has shown that while India in relation to other sectors of research, the payoff from investment on agricultural research in our country has been one of the greatest in the world. Among factors which have contributed to the effectiveness of our agricultural research system is the development by the Indian Council of Agricultural Research of a national grid of cooperative experiments conducted by scientists belonging to all the relevant disciplines and institutions. Such all-India coordinated research projects now number over 70 and cover all the major areas of crop, animal and fish improvement. The data collected in such projects are discussed at all-India workshops and decisions on recommendations to development agencies and farmers and made collectively by all the concerned scientists. Another important strength of our research system is the direct linkages which have been established between the research centres and the farmer through national and mini-kit demonstration, krishi melas and revelling seminars. This feed back relationship assists in the fine tuning of the research apparatus to the needs of its clients. Though impressive in terms of contributions, our research efforts are still very small in relation to the magnitude and diversity of problems facing us.

I shall now turn to some of our major liabilities.

Liabilities

The low productivity of our agricultural systems is well known and comparative statistics place our country in the bottom group with reference to the yield per hectare of

many economic plants like rice, wheat, jowar, maize, pulses, oilseeds and cotton. An important reason for our relatively poor average agricultural productivity is the vast areas under the important crops, which include considerable marginal lands. Historically, cropping systems have evolved partially due to ecological and pest and disease compulsions but more importantly, on the basis of the home needs of the farmer and his family. We now know that many low-yield environments for rice or wheat may constitute high-yield environments for some pulse or oilseed crops. An effective food distribution machinery can pave the way for re-adjustments in crop planning based on considerations of ecology and economics. If this is not done, our agriculture will become increasingly inefficient and expensive and our cost of production will increase, since wages tend to rise with or without co-incident improvement in productivity. For example, our average rice yield now is about 1170 kg. per hectare and if the tentative Fifth Plan projection of productivity improvement is all that we can achieve, the average yield will be 1375 kg./ha. by 1979. In contrast, the average yield of rice even in 1971 was over 5000 kg. per hectare in the Arab Republic of Egypt, Japan, Italy, the United States and several other countries. Thus, after the in adequacy of farm power, a major handicap is defective land and water use resulting in low yields.

Probability estimates

I mentioned earlier that one of our great natural assets is variability in weather and soil conditions which fostered the domestication of a wide range of economic plants and animals. Aberrations in weather, however, also constitute a major handicap. The rainfall distribution is skewed, about 80% occurring during the south-west monsoon season. About 30% of our geographical area receives annually less than 75 cm

rainfall and the occurrence of drought, floods, breaks in monsoon, cyclonic storms, thunderstorms and duststorms are common in one part of the country or the other. Although the periodicity of such weather aberrations cannot be determined with precision, it is possible to work out anticipatory measures and cropping systems on the basis of probability estimates. This is yet to be done systematically.

The next major handicap is the growing loss of soil and the damage that is being done to soil health and fertility. For reasons which are not clear to me, there has been a great neglect of the soil in our country in comparison with China or Japan. While it takes anywhere between 100 to 400 years for one centimetre of top soil to be formed in nature, all this soil can be lost in just one year due to erosion. It has been estimated that nearly 60 million hectares out of the 139 million hectares under cultivation require attention from the soil conservation point of view. A wide range of factors such as denudation of forests and vegetation cover, inappropriate tillage and cropping techniques and practices like shifting cultivation, are causing a considerable loss of valuable soil through water and wind erosion.

Shifting cultivation, known as jhuming in the north-eastern Himalayan region, involves cutting down all vegetation from hill slope, use of fire to clear the debris, growing a crop like a hill paddy, millets, sweet potato or beans, abandoning the land after a few years and restarting the cycle at another place. According to an FAO estimate, this form of cultivation dates back to the Neolithic period. While this practice has gradually tended to disappear from states like Bihar, Orissa and Madhya Pradesh, the area cleared annually for jhuming may be about 100,000 hectares in Assam and Meghalaya Observations in Assam hills indicate that at least 10 centimetres of soil may be washed away even from moderate

slopes in each jhuming cycle. One of the factors influencing such indifference to soil care is the fact that the land cleared for jhuming is not owned by the cultivator, whose interest in the land is co-terminus with the cropping cycle. Shifting cultivation as well as growing one crop once in two to three years were two of the ancient methods of overcoming the implications of the law of the diminishing return of the soil in relation to crop yield. In areas with settled cultivation. application of organic wastes and the cultivation of pulse crops and other legumes which can fix atmospheric nitrogen in the soil were the common methods of restoring soil fertility adopted in the past.

Soil conservation

Soil erosion leads to an enormous loss of nutrients. Some calculations show that the annual loss of soil due to erosion is about 6,000 million tonnes of phosphorus and 2·6 million tonnes of potash. A portion of these nutrients may get deposited elsewhere. In fact, such loss of nutrients may be the most important cause of water pollution in our country. A major approach to soil conservation has been construction of contour bunds for the purpose of decreasing erosion, conserving water above the bund and increasing infiltration. We have so far treated, during the various Plan periods, about 13.3 million hectares of agricultural land and 1·2 million hectares of non-agricultural land with various soil conservation measures. While these programmes have been very valuable both for deminishing erosion and providing employment, the agricultural benefits from such programmes have not been commensurate either with the effort or expenditure involved. Often bunding has neither been followed up with other measures like providing a vegetation cover nor has it been carried out with an under-

standing of crop production technology. For example, a recent survey by the Madhya Pradesh Department of Agriculture on the effectiveness of contour bunds in increasing rabi wheat yields has shown that on the whole the effect of bunding was strongly negative. Similarly, a study on the effect of bunding on the yield of kharif crops in the Bellary area indicated that contour bunding decreased the yields of jowar, cotton and sunflower both as a result of water stagnation and delay in cultural operations. It is obvious therefore that soil conservation measures need to be planned and implemented in a much more scientific manner taking into consideration not only the need to check erosion but also the end purpose of promoting crop growth.

One has only to see how land is being used for brick making and road making in our country to understand the extent of indifference to the care of the soil. While planned use of land for brick making could help in building up permanent assets like tanks, unplanned use results both in the loss of good agricultural land and in erosion. Similarly, there is always a danger that natural drains may be plugged if a total view on soil and water conservation is not taken while planning the construction of roads and railway lines. Closing natural drains leads to floods and thereby to considerable soil erosion. Thus, deforestation, shifting cultivation, overgrazing and improper cropping of undulating lands, bunding without vegetation cover, plugging of natural drains and other kinds of poor land management are causing increased runoff, reduced ground water recharge and severe erosion resulting in the deterioration of soil, loss of valuable nutrients, lower yields, flooding of lowland areas, sedimentation of small tanks and large reservoirs and the wastage of precious water to the ocean. It is not hence surprising that in an article entitled "The Eleventh Commandment", Dr.

W. C. Lowdermilk stated a few years ago that "the use of land is a down-to-earth index of a civilisation, for land has been the silent partner in the rise and fall of civilisations."

We can continue to neglect our soil only at the peril of our future. The authors of Limits to Growth have calculated that every child born today would need 0.08 hectare of land for purposes like housing, roads, waste disposal power supply and other uses and 0.4 hectare of land for producing the food he or she needs. On this formula, we will need at least 5 million hectares of additional land every year to cater to the needs of those added to our population. In contrast even in 1969-70, the availability of agricultural land was only 0.34 hectare per person. Obviously, it is time we woke up and spread throughout the country a consciousness of the value of soil and the importance of scientific land use.

Improper and inefficient water use, inadequate tapping of sunlight, poor utilisation of biological nitrogen fixation, wasteful disposal of wastes, lack of understanding of recycling processes and power integration of crop and animal husbandry on the one hand, and terrestrial and aquatic production systems on the other, are some of our other major liabilities.

The low pacc of progress in getting the best out of our water resources is evident both from the relative stagnation in kharif crop production and the low intensity of farming. During kharif season, when much of the rainfall is received, the production of foodgrains was 65·6 and 62·0 million tonnes in 1964–65 and 1971–72 respectively. In contrast, the rabi production during these two years was respectively 23·7 and 42·7 million tonnes. Thus our major grains in production have come from the non-rainy season. With the development of irrigation facilities it should have been

possible to bring more area under double and multiple cropping, thereby raising the intensity of cropping. The intensity of cropping is however still low, and has risen from 114 per cent in 1965–66 to only 117 per cent in 1969–70.

A low intensity of cropping even when water is available also implies a poor utilisation of sunlight, since in the tropics and sub-tropics green plants can be made to produce food, feed and fodder continuously by photosynthesis from water and atmospheric carbon dioxide. The cellulose produced by photosynthesis on the earth is not only the chief basis of all fossil fuels, but also the most abundant renewable raw material currently available.

Nutrient supply

In the area of nutrient supply to crops, organic manures like farm-yard manure, compost, green manure, various oilcakes and various waste products of animal origin like dried blood, bones, fish manure and urine had been used in the past. With the growth in population, farm-yard manure and other organic wastes have increasingly been diverted to fuel purposes. Though some work has been done on the generation of gas from such wastes in order to obtain both fuel and manure from the same material, such techniques have not come into use on any significant scale. Much of the urban wastes, sewage water, cattle and human urine and human excreta are not recycled in a manner that will promote productivity.

A great marvel of nature is the way in which micro-organisms fix atmospheric nitrogen in the soil largely through leguminous plants. While synthetic nitrogen - fertiliser production requires very high temperature and pressure for combining nitrogen, hydrogen and oxygen, the nitrogen-fixing organisms like Azetobactor, Rhozobium and blue-green

algae are able to do this at ordinary soil temperature and pressure, with the help of the enzyme nitrogenase. Nitrogen is now being introduced into the earth in fixed form at the rate of about 92 million tonnes per year, whereas the total amount being denitrified and returned to the atmosphere is only about 83 milion tonnes per year. The difference of 9 million tonnes per year may represent the rate at which fixed nitrogen is building up in the soil, ground water, rivers, lakes and oceans. Unfortunately, studies show that while Australia, the United States and Soviet Union are adding every year substantial nitrogen to their soils, we may have a negative nitrogen balance.

First among the emerging concepts of management of biological assets is attention to economic ecology. I used the prefix "economic" before "ecology" to underline the fact that what we need is as high an economic growth rate as possible through the use of the principles of ecology rather than the kind of ecology discussed frequently in the affluent nations which is of the conservationist or zero growth rate kind, intended to preserve the high standards of living already achieved. For the sake of convenience, I would like to deal with our arable land in five groups—arid, semi-arid, humid, irrigated and hilly regions. It is obvious that there are numerous climatic variations in these groups. Kharif and rabi seasons have not the same significance in south India, as they have in the north. This is why agricultural technology becomes highly location and situation specific, necessitating a considerable amount of local research and testing work, before a new technology can be recommended to the farmers. While ideas and concepts can be transplanted from one region to another, the actual material and techniques will have to be tailored to suit the local agro-ecological and socio-economic *milieu*.

Intensification of dryland research

The new phase of dry farming research, although only 3 years old, has already resulted in considerable data on better moisture conservation and use, new cropping patterns, crop life-saving techniques and mid-season corrections in crop planning in the drought-prone areas. The pilot project areas attached to the dry farming research centres are helping to identify the socio-economic and operational constraints in the transfer of the technology from the research farm to the farmer's fields.

Since water is the major limiting factor, a priority area of research is the standardisation of techniques by which as much of the precipitation as possible can be conserved for crop use, either directly in the soil profile through infiltration or through run-off collection and storage. Deep ploughing, for example, promotes a vertical rather than a tangential flow of water in red soils with a dense sub-soil. The cultivation of deep rooted crops like castor, red gram or arhar and cotton further helps in improving the soil texture and in adding organic matter through root deposition. Run-off storage structures are being developed both for individual small farms and for larger water sheds. Obviously, the most effective method will be the co-operative management of an entire water shed. If sufficient water can be collected in community owned ponds, a life-saving irrigation can be given at the time of grain formation, when the crop will benefit most from the supply of a little water.

In black soil areas with moderate rainfall, there is scope for double cropping or ratooning, provided suitable surface drainage can be introduced during the rainy season and appropriate tillage practices can be developed. Drainage and sound soil and water management will again need some

degree of cooperative endeavour on the part of a water-shed community. There is also great scope for introducing better inter-cropping practices in areas with annual rainfall ranging from 625 to 1000 mm.

Drought-escaping varieties

Progress has been made in identifying crop varieties which are relatively photo-insensitive and which have a shorter duration and the resulting ability to escape droughts. Early seedling vigour and good population performance are the other attributes of such strains. Suitable varieties in rice, jowar, bajra, minor millets, sunflower, safflower, castor, mustard, groundnut, pulses like moong, urad, arhar, and cowpea and cotton are becoming available As a result, different cropping patterns can be developed to suit different weather models. For example, some of the common weather aberrations are (a) early or delayed onset of monsoon, (b) long breaks in the monsoon and (c) inadequate rainfall and different crop schedules can be developed for each of these conditions. If the monsoon is very early, short duration legumes could be taken followed by regular season crops. For normal sowing, jowar, for late sowing, bajra, and for very late sowing setaria are some of the possibilities. When there are long breaks in the monsoon, the jowar or bajra crops affected by drought could be ratooned. Crops with indeterminate growth habits such as castor or arhar regenerate fast if given an area spray after the receipt of rains during a prolonged drought period.

Multiple and relay cropping

The potential of irrigated areas to produce much higher quantities of food, feed, fibre and fodder plants through multiple and relay cropping is now well known. Due to

various difficulties and shortcomings in the water conveyance and delivery system as well as due to shortage of power, fertilizer and good seed, the full potential of the irrigated areas is yet to be realized. If these defects are overcome and minimum of two good crops can be raised the production of about 8 to 10 tonnes of food and other grains per hectare per year, now being harvested in several of the experimental stations of agricultural universities, should not be beyond the reach of many small farmers. While taking up intensive farming practices, a continuous monitoring of the soil for major and micronutrients and for pathogens will be essential. Legumes should find a place in the rotation and as a rule, crops sharing common pests and diseases should not succeed each other. It would be better to alternate deep and shallow rooted crops so as to tap nutrients from different soil layers.

New systems of cropping are rapidly coming into existence in many of our irrigated areas. Thus, in the Punjab and Haryana, rice during kharif and wheat during rabi is gaining popularity. In West Bengal, wheat is becoming popular as a rabi crop in rice fields. Baisakhi moong and other strains developed in order to find place for a pulse crop during a season when the land is normally fallow are becoming popular as summer crops. In the rice fallows of South India, jowar, bajra and cotton can be raised during the off-seasons. In the case of several of these new cropping patterns, we need much more data on the most appropriate cultural practices including fertilizers application and weed control.

Effective land use

Our knowledge of the most effective land use systems in the heavy rainfall areas is still fragmentary. Many of these

areas, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Mizoram, Tripura, Manipur and Kerala grow plantation crops and fruit trees in the medium and higher elevations. A viable alternative to shifting cultivation has to be found in the north-eastern Himalayan region. Similarly in Kerala and Karnataka, there is very little data on the optimum utilisation of garden lands occupied by crops like coconut, arecanut, mango and jackfruit. Prof. K. N. Raj and his colleagues have recently pointed out that the current crop-mix in garden lands of Kerala and Mysore is the product of the technological possibilities as known until now to the farmers of these areas but that a fresh look is needed since the market conditions for some products as, for example, arecanut, have considerably changed. By appropriate changes in spacing in coconut and arecanut, some other crops of high value like cocoa, cloves and soy-beans can be grown in between the palms. New varieties of grasses and legumes are available now which can also be grown as inter-crops in the arecanut or coconut plantations so that the farmer can maintain a few cross-bred cows for milk production. These and many other possibilities for capitalising on the ecological possibilities of the humid tropic regions are yet to receive intensive attention.

Changing plant architecture

The search for synargy has led both to the re-patterning of plant achitecture in many economic plants and to the development of cross-bred farm animals which are efficient in the conversion of feed into the product for which they are raised by man. What the breeders now look for are the plant types which can maximise production per unit of area, time and water. Thus, plant types which will not shade each other or fall over each other and which will promote better

light interception and carbon dioxide fixation are now sought after. In the earlier strains, many of the characteristics had been selected for performance under adverse circumstances and not for high yield under good management. Because of their plant and leaf characters, a larger number of productive tillers per square metre can be packed into the new varieties of wheat and rice, as compared to the old ones. Similarly, the distribution of the total dry matter produced by the plant between the part of commercial value and the remaining parts is much more favourable in the new strains. New plant types in bajra can respond to a population density of about 250,000 plants per hectare, in contrast to less than 100,000 plants in the case of the earlier strains. Similarly, in maize, dwarf varieties with smaller tassel, high nitrate-reductase activity and upper placement of the ear are under testing in several countries and these can respond to a population density of about 150,000 plants per hectare. The concept of population explosion in fields has also permeated horticulture. Growingly, emphasis is being placed in orchards on the selection of dwarfing root stocks. Some experts believe that the fruit orchards of the future may be "liliputian" in nature, facilitating a high management efficiency. Unfortunately, in our country root stock consciousness has not yet spread and citrus growers still raise orchards from seedlings although budded plants on appropriate root stocks like trifoliate root stock in drought prone areas can make a great difference in orchard productivity.

Apart from improving population performance and the yield potential of economic plants through a repatterning of plant architecture, growth rhythm and allocation of dry matter between the commercial and non-commercial portions of the plant, the other areas of concern have been in introducing a broad spectrum of resistance to pests and

pathogens and in improving nutritional and cooking or processing quality. Unfortunately, breeding for resistance to pests and diseases is often a never-ending task. The resistance tends to break down, following the build-up in nature of new races of the pathogen capable of attacking a variety earlier released for its resistance. We are now witnessing this in the popular wheat varieties Kalyan Sona and Sonalika, which at the time of their release in 1967, had a high degree of resistance to brown and yellow rusts. Kalyan Sona has become susceptible particularly to brown rust and there is no assurance that the resistance of Sonalika may hold out for long. Seeds of new strains have hence to be multiplied and distributed speedily. Dynamic varietal diversification and seed multiplication programmes are essential to sustain a good crop production programme.

Outwitting the pathogen

Will the struggle between the breeder and pathogen be an endless one or will one outwit the other? This is an interesting question for which no clear-cut answer is yet in sight. The breeder is adopting a multipronged strategy. He is working on a type of resistance, technically referred to as horizontal or field resistance, which is likely to be of a more enduring type. He is also trying to develop escape mechanisms by trying to alter the growth phase of the plant in such a way that it does not synchronise with the peak multiplication and infectious phase of the pathogen. He is striving to develop strains called "composite varieties" which can help to reduce the pressure on the pathogen in building up new and virulent races. He is also trying to understand the biochemistry and physiology of resistance, hoping in this way to find effective and cheap chemical methods of control. While all these approaches need to be followed with vigour,

our immediate hopes lie in the genes for resistance found in the primitive cultivars and other wild and cultivated genetic material occurring particularly in the centres of diversity of plants. Thus, the rich collections of rice made by our scientists from the north-eastern Himalayas contain genes for resistance to a wide range of pests and pathogens infecting rice. Areas where the pests are endemic provide opportunities for screening for resistance. Under our all-India co-ordinated research programmes, such areas have been identified, and given an efficient seed multiplication and distribution machinery, we should be able to remain ahead of the pathogen in several crops.

Cutting post-harvest losses

Techniques are also becoming available for minimising losses during harvest and post-harvest operations. A major problem in the safe storage of grains is the high moisture content often found, particularly in paddy. We need much more work on the standardisation of effective methods of preventing pre- and post-harvest losses in grains, fruits and vegetables under different ecological conditions. Bad storage not only results in a quantitative loss of all food material, but more importantly, there could be considerable deterioration in nutritive quality. The problem is acute in crops like groundnut which develop aflatoxins following fungal infection.

An exciting era

We are thus in an exciting era in agricultural and food science Thanks to the growing involvement of more and more physicists, is chemists, climatologists, mathematicians and engineers in studying and solving biological problems, we can hope for continued progress in unravelling new approaches

to improved productivity. Remote sensing, satellite photography and satellite television have all great applications in soil and ground water survey, crop censussing, disease forecasting, prediction of floods and cyclones and mass communication. The National Commission on Agriculture in their report on Agricultural Research and Education have stressed that in our legitimate concern for results of immediate applied value, we should not dry up sources of basic research. Research in production physiology, molecular biology, cellular biochemistry, design engineering, construction of production models on the basis of a systems approach, all deserve to be supported and intensified. If some of the current experiments designed to confer the ability for biological nitrogen fixation on cereal crops, thus making them behave like legumes, meet with success during the next 10 years or so, this will be one of the greatest boons that scientists can confer on the poor cultivators. There is evidence that the current highest yields obtained in wheat and rice represent less than half of what is theoretically possible. Scientists have hence much to do.

Village level co-operation

···The emerging agricultural technology is of two major kinds with regard to the case of adoption. In one kind, as for example, the new technology of wheat cultivation, the economic benefits derived by a farmer by adopting the technology are not influenced by what his neighbouring farmer does or does not do. In other words, the technology is capable of successful individual adoption, in economic terms. In the other kind, the economic benefits conferred by the technology on the farmer will be proportional to the extent of co-operative action generated on the part of an entire village or watershed community. Rice and cotton

cultivation and prevention of disease epidemics in cattle are good examples. Even in the Punjab, with one of the finest farming communities in the world, the average yield of cotton is low, being only 368 kg./ha. In contrast, in the Arab Republic of Egypt where cotton cultivation is managed co-operatively without any infringement of individual ownership, the average yield is 780 kg./ha. Pest control and water management in view are best done co-operatively in a village. In fact, if this can be accomplished, even some of the fertilizer lost through leaching in drainage water can be recycled, by collecting such water in a pond at the lowest point and re-distributing it. I have already stressed the need for achieving a doubling in fertilizer response from the present low level of about 10 kg. of grain per kg. of NPK nutrients. I also pointed out earlier that the emerging concept of pest avoidance is pest management and not just chemical control. All these aspects of the new technology would need understanding and co-operation among neighbouring small farmers. If this is not achieved, the risk element in crop production will be high. A low-cost and low-effort agriculture will be the poor cultivator's response to a high-risk farming situation, unless he has protection by means such as crop insurance. This is an important reason for the relative stagnation of kharif crop production in our country, where in spite of moisture availability, the farmer hesitates to invest on inputs in areas which are prone to pests and diseases, water-logging and operational problems in land preparation.

Co-operative effort is not only needed in the delta areas during the kharif season but even more importantly, in the dry farming regions. While an individual farmer can increase the storage of moisture in the soil profile of his own field through tillage, mulching and other measures, the

possibilities for collecting all the run-off water and using it for a crop life-saving irrigation later, can be realised only if there is group action in accordance with the topo-sequence of the farms.

Social synergy

What is social synergy ? Ruth Beneditct, the anthropologist who first applied the concept of synergy in social sciences, says and I quote, "Societies where non-aggression is conspicuous have social orders in which the individual by the same act and at the same time serves his own advantage and that of the group...Non–aggression occurs in these societies not because people are unselfish and put social obligations above personal desires, but because social arrangements make these two identical.

Cultures with low social synergy are those in which the social structure provides for acts which are mutually opposed and counteractive, and cultures of high synergy where it provides for acts which are mutually reinforcing...In cultures with high social synergy, institutions ensure mutual advantage from their undertakings, while in societies with low social synergy the advantage of one individual becomes a victory over another and the majority who are not victorious must shift as they can."

According to Abraham Maslow, "The high synergy society is the one in which virtue pays···High synergy societies all have techniques for working off humiliation, and the low synergy societies uniformly do not."

To a biologist like me, there is sufficient evidence in nature to prove that symbiosis, or the process of mutual assistance and support, is a necessary ingredient for synergy. However, it seems that the very concept of synergy has been

very little used, or even understood, by social scientists in its application to man. Ruth Benedict was one of the few social scientists to apply this concept to societies, and it has been later developed by Abraham Maslow, who is, significantly enough, not considered an orthodox psychologist. A very significant definition of social synergy is the one I just quoted. From this, it appears that there is a close correlation between synergy and non-violence, a fact which should be of interest to us in the country of Mahatma Gandhi. Further high synergy society seems to be another name for what Gandhiji described as the Sarvodaya society. It is also evident that our society as at present organised is a low synergy society. What steps can we take to ensure that we move from this to a better state of affairs ?

Individual and social goals

Individual goals have to be made to coincide with social goals. This can be done in many ways. The Communist countries have found their own approaches. Russia, China and Israel have all found their own ways of ensuring this merging of individual and social goals. Most of these methods are related to the practices of child-rearing and education. In Soviet Russia, for instance, the system of rewards and punishments in schools is such that the individual is rewarded only when the peer group succeeds. At every stage, the success and happiness of the individual is related to the success of the group in such a way that each individual strives to maximise the success of the group, such as encouraging children and students to take up economic projects in a responsible way, and linking them with academic success, would be good examples of social synergy at work.

This is not however the only means of achieving the goal. In a free economy, it is possible to conceive of a

system whereby farmers could be motivated to produce what the nation considered necessary. This would involve a very complex act of arrangements including pricing, availability of inputs, technical knowledge, land ownership and a variety of other things. However, it is clear that slogans and appeals to the social conscience cannot work, except for short periods during the national crises. 'Grow More Food' or 'Self-reliance' are not adequate as methods to persuade farmers even to grow anything, leave alone to do so in an ecologically balanced manner. It requires a far more widespread and dynamic movement of society to bring about such changes. In other words, it requires a release of synergy.

A technology for the poor farmer

...I have so far spoken about an agriculture in which the ecological advantages of the different parts of our country can be maximised and the hazards minimised through appropriate land and water use planning in which high synergy crop and animal production systems are introduced, recycling procedures used to promote a high growth rate in productivity on the basis of renewable resources of energy, farm and factory are closely linked, maximum economy and efficiency effected in the use of all resources, export markets nurtured through continuous attention to the changing quality needs of the clients and a fair and remunerative return assured to the primary producer. This is an agriculture based on ecological awareness, in which synergy, harmony and economy are the basic principles, and of which recycling is a tool. These in essence the principles on which Mahatma Gandhi developed most of his concepts of rural reconstruction, though he used a different language and a different set of examples which were valid at that time. We should not make the mistake of rejecting the principles because some of the examples used

by Gandhiji forty years ago may be out of date in the light of modern science. On the contrary, science and technology have in their search for a productive agriculture compatible with human growth and human welfare, uncovered the very same principles which Gandhiji arrived at by a different route. If we can take the steps necessary to evolve the kind of agricultural system I have described so far, based on the most advanced principles of biological science, we can probably claim to have developed a Gandhian Agriculture, because this would be an agriculture where Gandhian concepts become manifested in the form of an advanced rural economy, benefiting all sections of the community.

To achieve this, the tool has to be education, and the chosen method, co-operation. Social synergy has to be released by using appropriate educational and organisational methods as catalysts. In addition to official extension agencies, we have numerous workers belonging to the Gandhian and Sarvodaya movements, missionary groups, voluntary service societies and others, who are dedicated servants of the rural poor, struggling with zeal and devotion to transform the face of rural India. What they lack are the tools and the understanding of a modern agricultural technology which can help them to achieve their aims. I hope the staff and students of the Bangalore University will strive to spearhead the rural regeneration movement.

Science and Social Change

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Science, as an operational force, has to be taken in conjunction with the technology that results from the application of science, and, which in turn leads to the further growth of science. So, when I talk about science, I shall normally be referring to both science and technology. True, science *qua* science can have an independent operational role on the minds of men, especially in the way they think about men and matters ; but, by and large, science shows its effect by its practical application and the visible changes it brings about through the use of technology.

There can be no questioning the fact that during the last 200 years, science and technology have brought about vast changes in the world we live in, our relation to it. and in ourselves. The major impact has been on methods of production with a manifold increase in the output of goods and services or what the economist would call the national income or the G. N. P. It is, however, not only the techniques of production that have changed. Contributing to it but also having independent effects of their own have been the changes that have taken place in transport, communication, energy, construction, medicine, weaponry, and genetics. In turn this has been responsible for changes in the way of life of people, their demographic pattern, housing, urbanisa-

tion, family life, education, recreation and health care. As consequence of all these changes, there also take place changes in human relations, changes in the human being's conception of himself, and changes in what may broadly be described as values, individual, social and spiritual. All these changes have the nature not only of cause and effect, but also of effect and cause. In other words, all change is mutually connected, making change a continuing process that never gets fully integrated at any one point of time. Thus the supreme reality in all observed phenomenon is change. It is only when one gets into the realm of mystical experience that one can talk of unchanging reality such as God or the individual soul or eternal values that are independent of time, space and interaction.

After this brief but somewhat formidably philosophic introduction, we may now turn to the subject of science and social change in India.

Modern science came to this country with the British connection and the establishment of universities with faculties of science, engineering, agriculture, and medicine during the 19th century. Its impact quickened during the first half of the 20th century, indigenous contributions adding to the wealth of science and technology imported from abroad. With the advent of Independence in 1947, the national establishment of social, political and economic goals, the recourse to planned development, and the commitment to science and technology on the part of the Indian Government largely under the inspiration of Jawaharlal Nehru, the pace of progress in both knowledge and application of science and technology grew by leaps and bounds in India. The result has been an extent of social change that appears to have had no parallel in any previous period of recorded Indian history.

The major change resulting from the application of science and technology has been in the methods of production. In agriculture, extension of irrigation has been accompanied by a radical change in the methods of production involving the use of mechanical implements, chemical fertilisers and pesticides, and high-yielding and fertiliser-responsive seeds. While this chemico-genetic revolution in agricultural technology has not covered either the majority of the agricultural crops or, even more, the bulk of the area under cultivation, and has had differential effects in both crop-wise and region-wise terms, it has certainly made a significant impact on agricultural production, especially of foodgrains and brought prosperity to certain selected rural classes and areas in the country. The changes that have taken place in the methods of industrial production have been more startling, not so much in terms of change in respect of existing industries and industrial processes as in the introduction of new industries and new industrial processes in the country, bringing about an expansion of industrial output in both volume and product-mix, with particular stress on chemical, engineering, capital goods, and intermediate goods industries. However, the impact of science and technology has not been so significant either on the volume or on the processes of consumption goods industries, except for durable consumption goods and other consumption goods catering to a class market. The phenomenal growth of the power industry has not only sustained the increase in industrial production and made for a more efficient use of well irrigation, but also helped the growth of small scale industrial units and brought electricity to more than 1,60,000 villages. The rapid growth of road transport has made possible a wide-ranging movement of raw materials and finished products and accelerated the growth of industrial concentration both by units and by areas. The development of our transport has also worked in the same

direction by facilitating coordination and centralisation of decision making in both economic and political spheres. The development of education has not only helped to produce the supply of technical and scientific skills needed for the country's economic development but also brought westernisation and modernity in our society, besides *Sanskritisation* among those who had traditionally occupied lower positions in the hierarchy of the Indian social structure. The development of health facilities and medical aid has led to a reduction in the death rate, brought about an increase in India's population by more than 180 million within two decades and raised the average expectation of life while simultaneously increasing the proportion of the young in the population. It has made possible the prevention of births and facilitated the exercise of control over the size of family. The changes wrought in the economy by the application of science and technology have also resulted in a startling increase in urbanisation. While the proportion of urban to total population in India is still a little less than 20 per cent, our urban population exceeds the total population of most of the developed and industrialised countries of the world with the exception of the United States and numbered about 109 million persons in 1971 of whom nearly 61 millions are to be found in cities with a population of over 1,00,000 each and of whose number 34.6 millions or as much as 57 per cent have been the additions made during the last two decades. The development of communications brought about by science and technology has led to an enormous increase in the use of radio receivers in absolute numbers, though not impressive in terms of its proportion to the population, together with the cinema and popular periodicals, the communication media have had a significant impact on cultural habits and values in Indian society. Altogether, though India still ranks as an underdeveloped country, or at best, as a developing country

but with one of the lowest per capita incomes in the world. there is no doubt that there has been a remarkable development of science and technology in the country, specially after the advent of independence. And this, in turn, has had a profound impact on material conditions in Indian society and brought about a significant measure of social change in India during the last two to three decades.

I shall now proceed to deal with some of the more important aspects of this social change, though necessarily the treatment will be both brief and selective for considerations of time as also the work that a more comprehensive treatment would have involved.

To identify social change, one has to look at what has happened in the traditional structure of Indian society, and its institutions like caste, the joint Hindu family, marriage, status of women, untouchability, ceremonials and customs, and religion. The extent to which Indian traditional society has altered and the nature af the alteration that has taken place would be the most significant aspect of the social change that science and technology and their application have brought about in India.

Caste has been the strongest and most traditional form of social grouping in India, not so much in terms of the original fourfold caste system harking back to the *Purushasukta* but in terms of the numerous sub-castes that have formed themselves under the original four and have many permutations and combinations on the basis of language, region, and local peculiarities. And caste has sustained itself not only because of its base in heredity but also because of the internal ties it promotes amongst its members through marriage and kinship. The continued strength of the caste system also rested on its social codes, food habits and taboos, residential

proximity, occupational links and identities, and rituals and religious practices. The changes effected by the application of science and technology by way of industrialisation, mechanisation, urbanisation, demand for new skills and the provision for facilities to obtain the same without restrictions based on caste or heredity, the propinquity created by the new methods of transport, the mobility created by the changing economic system and the extending spheres of Government, the scepticism generated for the traditional religious sanction for caste restrictions by the new education, the new influences created by films and the literature of scepticism on the masses, and the wooing of the traditionally lower castes by politicians who had to find their activity in a political system based on adult franchise and periodic elections—all these had their inevitable impact on the working of the caste system in India. The new industrial occupations and service professions, the new towns and cities, the new transport system, the new educational centres and the operation of new political forces all brought about proximity and propinquity among members of different castes, diluted if not eliminated their isolations and exclusiveness, and built up a new social life and new social relations that broke the old caste barriers. The process did not, however, proceed to its logical conclusion and result in the disappearance of the caste system. This was due, partly no doubt to the regrouping and revival of religious caste leaderships. But the stronger and much more pervasive factor that came to the rescue of the caste system was the new use to which the social groupings with their traditional caste solidarity could be put in the context of a political democracy based on adult franchise and periodic elections. Caste groups formed a reliable and readily available base for winning elections by individual candidates, though the political parties that sponsored them covered up this ugly reality by high sounding political and ideological

appeals. Caste, as a social group, also became an active instrument for sharing the spoils and patronage incidental to a democratic political system and a developing economy with its new opportunities. In addition, the Indian institution of marriage restricted choice of partners to the relevant caste, gave it powerful social sanction, and left it to be arranged by the parents concerned, which was facilitated by the comparatively early age at which marriages take place in India and the marriage-must that is dinned into the ears of girls in India almost from their childhood. The result has been that while caste has lost some of its external trappings and taboos, it still remains as a powerful social grouping, evoking exclusive loyalties, linked together by marriage and kinship, using its influence to get its share in economic, educational, and political opportunities, and throwing up a leadership that uses the caste to promote its own interest and also uses its power to better the lot of its own caste groups.

For completing the picture, I must also mention two other forces which are tending to undermine the caste system, though without any significant success so far. One is the new group that has emerged cutting across caste barriers, marrying outside their caste and even language and region, cultivating a western style of living, and forming a new all-India elite based on education, occupation, economic opportunities and government service. Some members of this group have taken full advantage of the mobility created by modern science and technology to establish their outposts even in foreign countries though largely confined to English speaking areas. While this group has not solidified itself into a caste, as it is not based on heredity, nor has any allegedly religious sanction, it is unlikely to do any serious damage to the caste system, as many of its members take full advantage of their original caste affiliations to better their own interests.

In the very long run, however, this new group may help to undermine the caste system, as the gap between its profession and practice is bound to have its effect on the members of the caste systems it tries to exploit, and as its younger generation gets gradually influenced by its profession as against practice and may assume leadership for a genuine assault on the caste system.

The other and more genuine forces operating against the caste system are the trade unions and the genuine propagators and practitioners of socialist ideology. The institution of caste is wholly inconsistent with the concept of class. And as long as caste continues to dominate the Indian social structure, there can be no development of a genuine socialist democracy in this country. But socialist ideology is an accepted force in Indian political thinking, economic exploitation, income and wealth disparities, and mass poverty are also recognised facts in the Indian life of today. The combination of these two factors is bound to lead to the development of class consciousness and the erosion of caste loyalties and the ultimate elimination of the caste system in India. But all this will be in the very long run and who can say how long will it be. Meanwhile, I must confess that the impact of science and technology on the economy and on the material conditions of life and work in this country has not succeeded in shaking the strength of the caste system and to this extent, it has failed to effect a major social change that would have brought India in line with other countries which have experienced the impact of science and technology in equal and larger measure.

The position, however, is different in regard to some of the other traditional institutions in Indian society which I had listed earlier. The Hindu joint family, for example, has failed to withstand the impact of the operational effects of

science and technology. New industrial processes, changing forms of economic activity, increasing mobility of qualified or displaced individuals in search of better opportunities, transfers on service that are affecting increasingly large numbers of the technical, professional and administrative classes in both the public sector and the larger units in the private sector, and the increasing assertion for autonomous family life on the part of the younger generations—all these are leading to a rapid break up of the joint family system and its replacement by the nuclear family. This is, of course, more true of the urban areas, as in the rural areas the joint nature of the agricultural occupation still tends to sustain the joint family system.

Marriage as an institution still occupies its traditional position of strength in Indian society. But it is no longer addicted to pre-puberty and early age as in the not so distant past. The average age of marriage has been recording a steady rise, especially during the last three decades, with increasing education and women's participation in non-traditional economic and other activities. This is, of course, not so true of marriages among rural classes resident in rural areas. But the change is evident in urban areas, and conspicuous in the case of the more educated sections as also the elite in Indian society and especially of the new all-India group that I mentioned earlier as forming itself by crossing caste, language and regional barriers. Family planning, increasing preference for working women in marriage, divorce, and preference for the single state are all emerging in larger or smaller measure as noticeable phenomena in the more educated, sophisticated and urbanised sections of Indian society; and in due course the forces of *Sanskritisation* will tend to extend their influence in other sections of Indian society. Given the continuance of the forces of economic

and educational development, marriage as an institution is likely increasingly to shed its traditional association with early age, universality, and large families, and approximate to the institution of marriage as it has developed in the western world. But this will only be in the long run; and, even then, one cannot be certain in view of two factors that distinguish India from the western world, namely, its large number of villages and vast rural population, and the continuing hold of traditional religion on the Indian life style.

The most conspicuous change that has taken place in traditional institutions has been in the status of women in India. It is no doubt true that religion gave a high status to women in India and the Goddess has more worshippers than God. But in all things that matter in this material world, women in India have always been treated as inferior beings, deprived of both status and opportunities. That position has now undergone a radical change. Her right to ancestral property has been accepted. She now has the right to monogamy, divorce and maintenance. Educational facilities for women have been extended in large measure, her equality in status with man has been recognised by law and the constitution, and women are now playing an active role in all areas of national activity including the political and the economic. Domestic drudgery has also been reduced by the direct impact of science and technology on energy and gadgets for use in domestic work, thus releasing opportunities for women's activity outside the domestic sphere. True, all this has so far been largely confined to the more educated sections and upper echelons of Indian society. But the phenomenon is conspicuously visible and it is bound to set a trend that in due course and in the long run will give women in India a status and a position approximating to that of their sisters in the western world.

Another traditional institution that has received a mortal blow and will eventually disappear from Indian society is untouchability. The material developments resulting from the application of science and technology to which references have been made earlier have undoubtedly led to a recognition of the incompatibility of untouchability with development and the impossibility of its survival as an enduring institution. But while untouchability as such is tending, for most practical purposes, to disappear in urban areas, it has not disappeared in rural areas either in respect of residence or drinking water, and in many areas even in respect of other community facilities. Apart from the stronger hold of conservatism and traditionalism in rural areas, this has been mainly due to the negligible introduction of science and technology in rural life except in agricultural production and of course, the neglible share of property and means of production in the hands of Scheduled castes. While untouchability has largely disappeared in urban areas, the untouchables still remain under the nomenclature of the Scheduled Castes. And the Scheduled castes constitute the poorest, the most underprivileged and handicapped sections of Indian society with restricted opportunities and inadequate participation in the main streams of different areas of national and social activity ; and they numbered nearly 80 millions in 1971. Government, of course, is committed to their uplift and their getting a full share of opportunities in all spheres of national activity and has been attempting to implement a number of programmes for the purpose. But the pace of implementation is neither rapid nor adequate, genuine public support from other sections of Indian society is lacking and the way the whole problem is being handled both politically and by the public may lead to the Scheduled castes being used or getting wedded to a continuance of the caste system albeit in reverse gear, thus preventing the major social change

which is needed, namely, the destruction of the caste system and all that it implies for the creation of a truly democratic and socialist society in India. In the last analysis, the problem of the Scheduled castes is the problem of poverty. And the problem of poverty can only be solved by a politico-economic system that uses science and technology not only for increasing production but also for increasing employment and individual labour productivity and at the same time re-structuring property relations and investment patterns in such a way as to reduce disparities in income and wealth and improve the quality of life for the masses of the people. Such a system is democratic socialism, and democratic socialism has no place for casteist society.

Two other directions in which the impact of science and technology has made for social change in India are in the realm of national identity and cultural development. Thus, industrialisation, urbanisation, commercialisation and extension of educational facilities have led to a considerably larger measure of mobility and internal migration than in the past. And today we find a greater diversification of language, regional origin, religion and caste amongst our people who share work and residence than at any time in previous Indian history. While this is more particularly true of the big cities and towns, it is not entirely absent in rural areas. The social change this has brought about is of a mixed character. On the one hand, it has made for a sharper interaction between diverse social groups and given a new reality to the concept of Indianness. On the other hand, it has also given a new life to linguistic, regional and communal groupings, giving the country an uneasy balance between national identity and particularist identities in Indian political and social life. The necessities of economic development as also the growing opportunities it gives rise to has

also added to this conflicting trend in social change, namely, mobility in residence on grounds of efficiency and preference for the original residents in the name of a 'sons of the soil' theory. All this again is much more an urban rather than a rural phenomenon, as is the case with so many other aspects of the social change we are witnessing in India.

The other aspect of social change which has been influenced by the developments in science and technology has been in culture. While India has had a broad framework of cultural identity cutting across language and region and to some extent, even religion, indigenousness and immense diversity has marked its local manifestations in different parts of the country except for the elite of the land who had more of a national culture with a larger measure of non-indigenous origin. The material developments following the application of science and technology and the developments in transport, tourism, and mass communication media as well as the extension of primary and secondary education have tended to reduce this cultural gap between the elite and the rest, giving rise to a new mass culture of a polyglot character that cuts across not only class but also region, language and religion. The same forces have also given a new dynamism to some of the country's traditional and diversified cultures, with revivalism and uniformity seeking an uneasy co-existence and making for a culture of unity and diversity, if not one of unity in diversity.

As regards religion, rituals and ceremonials have not suffered in the manner one would expect during a period of such rapid development of science and technology and its application to Indian economic, educational, and other activity as has been witnessed in India since independence. The questioning attitude and increasing disregard for traditional forms and ceremonials of worship which marked the

later part of the 19th century in England and prevailed during most periods of modern development elsewhere has been somewhat conspicuous by its absence in India. Religious worship for securing the favours of the Deity for the promotion of one's personal or family interests has never been so rampant as in the India of the late 20th century. And developments in transport, communication and mass media made possible by science and technology have tended to increase rather than decrease the force of religiosity in India and its use for personal rather than social ends. Apart from religiosity, astrology has grown in stature and influence, logic and rationality have declined in matters other than technical, scientists are shedding their modesty and taking to wish-fulfilment projections and predictions, futurology is acquiring the status of a science, and new superstitions and prejudices are being added on to an already heavy pile accumulated through our long history. I think it is high time that the practitioners of science and technology turned their expertise on unravelling the mystery of how what is called a scientific temper is so absent in our country, why a scientific attitude is at such discount in matters other than purely scientific, and why scientific endeavour and technological goals are so poorly related to the achievement of a total enrichment of the quality of life for the masses of our people.

The conclusion I am reaching is that science and technology have not brought about that measure of social change in India which has been attributed to it elsewhere. And yet it is not wholly the fault of the Indian practitioners of science and technology. Partly of course it is. There is no denying at least an element of truth in the proposition that our science and technology have been largely west-inspired, big industry oriented and undoubtedly biased in favour of

capital and highly specialised expertise, accompanied by disregard for indigenous availabilities and constraints of resources and skills, and a lack of sensitiveness to mass requirements, rural needs, and backward regions. While the politician and the social scientist must share the major blame, the scientist and the technologist must also be held responsible for the dual society which has come up with such sharpness in our country during the last 25 years. It is the dual character of the society that has emerged in India that is responsible for the failure of science and technology to bring about the massive social change that it should have.

But, as I said before, the blame cannot rest wholly or even largely on science and technology. Our ethos has been urban, the complexes we inherited from our colonial past still persist, our aim has been to become modern which has been interpreted to mean western. And since we could not achieve western modernity for the whole of our country, we contented ourselves with creating it in a part of our country, which means the cities and big towns that house 61 million people, of whom one-third live in seven cities, whose population number more than a million people each. True there are pockets of western modernity and a few stray cases besides, in the rest of India. But the rest of India, which accounts for well-nigh 90 per cent of our population, and lives on agriculture, allied activities, traditional industries and service occupations, has had, except for some green revolution pockets, but little impact of science and technology either on its methods of production or its consumption habits and content or its housing or public amenities. Their life is neither western nor modern, but they constitute the bulk of India. This is the dual society we have in India, the crucial differential resting on the relative application of science and technology to their respective methods of work

and style of life. But this dual society does not function in compartments. It has a common government, common political parties, common mass-media, and common elections that temporarily overcome the duality to seek their verdicts on claimants to political power. There is also movement between the dual societies but not of an equi-directional character. In fact, it is a one-way traffic, from the rural and small town areas that house the non-modern and non-westernised majority of the Indian people to the cities and big towns that house the modern and westernised minority. Though the traffic moves in one way, it sends back to the houses of the immigrants a demonstration effect that adds to the frustration of their rural areas and adds to the sharpness of the dual nature of Indian society. But the dual societies are not entirely devoid of social identities. In fact they share some crucial identities in respect of their economic and social conditions. They both suffer from inequalities in income and wealth ; they both have large numbers of population below the poverty line ; and they both have sizable unemployment and underemployment among their number. These, combined with elections and political parties seeking popular support, have led to the emergence of socialist ideologies and are stimulating both the desire and the forces of social change. Unequal application of science and technology and unequal distribution of the dividends from development are thus the two major factors that account for the thrust towards a major social change in India. And the focus is on rural India. There is now a new emphasis on the part of both Government and of scientists and technologists on rural development. And Government is seeking not only the application of science and technology to different areas of rural development, but also attempting to restructure the institutional and social milieu in rural areas to ensure a more equitable distribution of the gains that result from develop-

ment. Simultaneously, the scientists and technologists are now discovering the social and economic institutional constraints that stand in the way of the successful application of their knowledge to rural problems, and have started stressing the importance of ensuring the non-scientific conditions for rural development. Altogether, it is a healthy sign for social change. If the political and scientific forces effectively operate their professed postures on development, they would undoubtedly strengthen the chances of a major break-through in the realm of social change in India. Whether the social change that will ensue will take us nearer to a modern and westernised society with its consumer dominance, gadgets, pollution and the ills of affluence or to a society of socialist complexion like in the Soviet Union or the People's Republic of China or to an altogether different but eclectic model with a Gandhian accent are all matters on which I am in no position to venture a categorical answer. But I do see that all these elements are in operation in larger or smaller measure, and there is always room for the unknown when one thinks of the future. Whatever be the society that will emerge, there is no doubt that science and technology will be playing an important role in shaping its content and contours.

I cannot end this lecture without again referring to one distressing absence of a result that is normally expected to flow from the development of science and technology in a traditional society. India's population has, by and large, not become mechanical minded and developed an attitude of do-it-yourself in the modern context. Nor has it developed a scientific temper and a rational approach that sets the mind free from traditional constraints and leads to a major change in men's relation both to themselves and to each other. We may be going in for modernity and westernisation in material

terms; but we still remain a feudal, custom-bound and superstitious society, with the added disadvantage of having developed a selfish and materialist outlook characteristic of a Western society. To my mind this presents a greater challenge to science and technology than even that posed by its lack of application to rural development. How far this is recognised by my colleagues among scientists and technologists and in what way and with what success they will meet it is more than I know or can even venture to guess.

Science and Religion

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1. Need to Foster the Scientific Spirit

Modern environmental and ecological problems may be making for the unpopularity of technology, or rather of over-technology, especially in advanced countries: but pure science, with its passion for truth and human welfare will always remain as one of the noblest pursuits of man: and our country, which has nurtured this love and pursuit of truth in the fields of physical sciences, religion and philosophy in the past, must continue to nurture it in all fields in the modern age. Religion and philosophy in India, as given to us in our Upanishadic tradition, is but the continuation of the scientific search for truth at the sense-data level to the higher aesthetic, ethical, and spiritual levels of experience, as I hope to show in the course of this address. I appreciate this pioneer effort of the Bangalore University to inculcate the scientific spirit among its students and staff and the general citizens. I wish, however, that the training of our people in the scientific attitude and outlook begins from the stage of primary education itself. That is the only way to purify and strengthen the rational and spiritual hertitage of our country by draining away its impure, weakening, and centuries-old contaminations of magic and superstition.

2. Relationship of Science and Religion : A New Approach

The subjects of science and religion are getting more and more important to man in the modern age. They are two great disciplines which, in the light of Indian wisdom, reveal that, when relied on separately, can be counter-productive in the long run, but, when combined harmoniously, can bring about an all-round expression of human genius and total fulfilment. But, unfortunately, for the last few centuries, the relationship between the two in the Western context, and everywhere else also due to the world-wide impact of Western culture, has not been quite happy. In the twentieth century, however, a new approach is becoming evident, and the representative thinkers among scientists and religious people are beginning to discern a close interrelation between them. They are slowly veering round to the point of view that science and religion can heartily embrace each other, without detriment to the cause for which each stands, and work for the good of humanity. It is being realised more and more by both that there are elements in science that religion can adopt in order to fortify itself, and elements in religion that can deepen and strengthen science. I shall here touch upon some of the sources of the discord between the two and the significance of the points of contact between them, and discuss the methods and results of both the disciplines, against the background, and in the light, of the unity and totality of all human knowledge and the synthetic and synoptic approach and vision of the Indian philosophical and spiritual tradition.

3. The Scientific Discipline

The civilisation in which we live today is the product of the discipline of the human mind known as modern science. When we study science at close quarters, in the way the great

scientists have applied themselves to this pursuit, we find two aspects to this discipline. The farst is *pure science*, science which tries earnestly to understand the truth of nature through a dispassionate inquiry ; and the second is *applied science*, in which the truth discovered by pure science flows as technical inventions for the enhancement and enrichment of human life. These two, science as *lucifera* and science as *fructifera*, science as *light* and science as *fruit*, are intimately related. Knowledge leads to power and power leads to control and manipulation of the forces of nature, enabling man to condition his life and environment with deliberation. Every new discovery in pure science, at some stage or other, becomes converted into applied science, into control and manipulation of the forces of nature. And the result, as revealed in recent history, is the great saga of modern scientific discovery and invention resulting in the world-wide technological civilisation of today. It is a most fascinating study how the human mind, disciplined in this pursuit of science, develops the capacity to wrest from nature truth after truth, hidden and jealously guarded by her, leading to our extraordinary modern age of nuclear science and space travel.

What is the nature of that movement of thought which has produced these remarkable results ? What do we mean by the term 'modern' as applied to thought, and what is the special feature of modern scientific thought which has rendered thought so explosive and revolutionary ? An answer to these questions will help us to reassess the role of the other great human disciplines, such as religion, ethics, art, politics and economics in the modern age.

The architect of the modern world is science, and by modern thought is meant scientific thought. The aim of science is to study nature and human experience objectively. To quote Karl Pearson (*Grammar of Science*, 1900, p. 6) :

> The classification of facts, the recognition of their sequence and relative signifiance, is the function of science, and the habit of forming a judgement upon these facts unbiased by personal feeling is characteristic of what may be termed the scientific frame of mind.

This quality of the scientific mind, and the mood and temper of its approach, have enabled science to wrest from nature its secrets, first from one field, then from another, and transform nature's forces into agencies for the service of man. The sum total of achievements in the theoretical and practical fields in the various departments of scientific inquiry in physics and chemistry, mathematics and astronomy, biology and psychology, as also in their various subsidiary branches, constitute an impressive record of human development, by the side of which long ages of past achievements in the same fields pale into insignificance. That is modern science in its methods and results.

4. Science versus Departments of Science

Science so understood is not tied up with any particular body of facts. In the words of one of the great biologists, J. Arthur Thomson (*Introduction to Science*, Home University Library edition, p.58) :

> Science is not wrapped up with any particular body of facts ; it is characterised as an intellectual attitude. It is not tied down to any particular methods of inquiry ; it is simply sincere critical thought, which admits conclusions only when these are based on evidence. *We may get a good lesson in scientific method from a businessman meeting some new practical problem, from a lawyer sifting evidence, or from a statesman framing a constructive bill.* (Italics not by the author).

Objectivity and precision, both as to thought and its verbal formulation, are two important characteristics of the scientific method. Any study possessing these characteristics

will be science, whatever be the field of that study. Science as such is, therefore, not tied down to any particular order of facts, though the various departments of science, like physics or chemistry, biology or sociology, are tied down to particular orders of facts. These departments have limited scope, but science itself is unlimited in scope; and these various departments, starting with the study of separate fields tend, in their advanced stages, to overstep their particular boundaries and merge into one converging scientific search, the search for the meaning of total experience. *In this expansive context, the idea of a science of religion, the science of the facts of the inner world of man, as upheld in ancient Indian thought, and as expounded in the modern age by Swami Vivekananda, becomes also a scientific study of far-reaching significance.*

5. The Spirit of Inquiry

The driving force behind this unique modern achievement is the spirit of free inquiry, characteristic of modern science. The mind that questions, and questions with a serious intent and purpose, and tests and verifies the answers it gets, has a dynamic quality about it, which enables it to forge ahead in the world of thought and things. In so forging ahead, it disturbs the wayside calm of untested dogmas and comfortable beliefs, and the magic and miracle and superstition wrongly associated with religion and leading to the vulgarisation of this great discipline. Science is verified knowledge. The explosive character of modern scientific thought is the product of the impact of a rapid succession of verified knowledge against an intractable fund of untested dogmas, assumptions, magic, miracle, beliefs, and superstitions. The organised opposition of the latter in the West sought to stifle scientific inquiry, first, at its birth and, later, at every stage of its progress. But the walls of the *bastille* of ignorance and

prejudice fell one by one before the onrushing waves of inquiry and illumination, illustrating the great saying of the Upanishad (*Mundaka Upanishad*, III. 1.6):

Satyameva jayate, nonrutam—'Truth alone triumphs, not untruth'.

The history of science in recent centuries is thus the history of the triumph of the spirit of free inquiry over mere opinion, untested belief, prejudice, and dogma. It is a remarkable adventure of the human spirit which has borne abundant fruits, not only mental but also material; for science as *lucifera* has flowed into science as *fructifera*, giving a bumper crop of discoveries and inventions which has transformed beyond recognition the world in which we live.

6. Eclipse of Dogma-bound Religion

The success of science has meant the defeat of its opponent. It is one of the unfortunate episodes of history, especially of modern European history, that the organisation of the forces of prejudice and blind belief against science and its spirit of inquiry came from the side of religion; and that reason, which was the life-breath of science, was viewed as the death-knell of religion. By the end of the last century, science had acquired high prestige and authority, while religion had been discredited, first, as a dangerous error and, later, as a harmless illusion.

The end of the nineteenth century thus saw the eclipse of religion in Europe. But there was an uneasy feeling in the hearts of many thinkers that something of deep value to man and his civilisation had been overthrown; and they attempted a reassessment of the meaning and scope of religion with a view to making it accord with the spirit and temper of science. To this great task of reconstructing the mental life of modern

man by bridging the gulf between faith and reason, on the basis of a unified view of man and a truer conception of the spiritual life, the contribution of Indian thought is unique and lasting.

7. Vivekananda on Reason and Religion

Tracing the recurring conflicts of science and religion in the West to the absence of a broad rational and experiential approach, Vivekananda said (*Complete Works.* Vol. II, ninth edition, p. 433) :

> We all know the theories of the cosmos according to the modern astronomers and physicists, and at the same time we all know how woefully they undermine the theology of Europe ; how these scientific discoveries that are made act as a bomb thrown at its stronghold ; and we know how theologians have in all times attempted to put down these researches.

When religion refuses to take the help of reason, it weakens itself. Alluding to this in the course of a lecture on 'Reason and Religion', delivered in England in 1896, Swami Vivekananda said (*ibid.*, Vol. 1, eleventh edition, p. 367) :

> The foundations have been all undermined, and the modern man, whatever he may say in public, knows in the privacy of his heart that he can no more "believe". Believing certain things because an organised body of priests tells him to believe, believing because it is written in certain books, believing because his people like him to believe, the modern man knows to be impossible for him. There are, of course, a number of people who seem to acquiesce in the so-called popular faith, but we also know for certain that they do not think. Their idea of belief may be better translated as "not-thinking-carelessness".

And pleading for the application of reason in the field of religion, he continued *(ibid.)* :

> Is religion to justify itself by the discoveries of reason through which every other science justifies itself? Are the same methods of investigation, which we apply to science and knowledge outside, to be applied to the science of religion? In my opinion, this must be so; and I am also of opinion that the sooner it is done the better. If a religion is destroyed by such investigations, it was then all the time useless unworthy superstition; and the sooner it goes the better. I am thoroughly convinced that its destruction would be the best thing that could happen. All that is dross will be taken off, no doubt, but the essential parts of religion will emerge triumphant out of this investigation. Not only will it be made scientific—as scientific at least, as any of the conclusions of physics or chemistry—but it will have greater strength, because physics or chemistry has no internal mandate to vouch for its truth, which religion has.

A study of the Upanishads reveals that the subject of religion was approached in ancient India in an objective, dispassionate manner; and the aim of the study was to get at truth, and not to hug pleasing fancies and illusions or to idolise tribal passions and prejudices.

In several of his lectures and discourses, Swami Vivekananda has expounded this scientific approach as upheld in Indian thought. In his lecture on 'Religion and Science', he says (*ibid.*, Vol. VI, sixth edition, p. 81):

> Experience is the only source of knowledge. In the world, religion is the only science where there is no surety, because it is not taught as a science of experience. This should not be. There is always, however, a small group of men who teach religion from experience. They are called mystics, and these mystics in every religion speak the same tongue and teach the same truth. This is the real science of religion. As mathematics in every part of the world does not differ, so the mystics do not differ. They are all similarly constituted and similarly situated. Their experience is the same; and this be-

comes law. ...Religion deals with the truth of the metaphysical world, just as chemistry and the other natural sciences deal with the truth of the physical world. The book one must read to learn chemistry is the book of nature. The book from which to learn religion is your own mind and heart. The sage is often ignorant of physical science, because he reads the wrong book—the book within ; and the scientist is too often ignorant of religion, because he too reads the wrong book—the book without.

The Indian thinkers discovered by their investigations that there are two fields in which man lives and functions: one, the external field; the other, the internal. These are two different orders of phenomena. The study of the one alone does not exhaust the whole range of experience. Also, the study of the one from the standpoint of the other will not also lead to satisfactory results. But the study of the one *in the light of the conclusions from the study of the other* is helpful and relevant.

Referring to this approach in the course of a lecture on 'Cosmology', Swami Vivekananda said (*ibid*., Vol. II ninth edition, p. 432) :

> There are two worlds, the microcosm and the macrocosm, the internal and the external. We get truth from both of these by means of experience. The truth gathered from internal experience is psychology, metaphysics and religion ; from external experience, the physical sciences. Now a perfect truth should be in harmony with experiences in both these worlds. The microcosm must bear testimony to the macrocosm, and the macrocosm to the microcosm ; physical truth must have its counterpart in the internal world, and the internal world must have its verification outside.

Thus the sages and thinkers of ancient India said : Here is the physical life of man, and here is the physical universe that environs him. Let us study both in a scientific spirit.

But let us also study him in his depths, his nature as revealed by his consciousness, his thoughts, his emotions, his ego, and his sense of selfhood. These latter also constitute a vast group of phenomena that need to be investigated. Every advance in this field is bound to advance man's knowledge about the truth of the mystery of the external world. For, to quote mathematician-astronomer the late Sir Arthur Eddington (*Philosophy of Physical Science*, p. 5):

> We have discovered that it is actually an aid in the search for knowledge to understand the nature of the knowledge which we seek.

8. The Upanishads and the Spirit of Critical Inquiry in India

Ever since the time of the Upanishads, India has tenaciously held to a view of religion which makes it a high adventure of the spirit, a converging life-endeavour to realise and grasp the hidden meaning of existence. Faith, in India, did not mean a cosy belief to rest by, but a torch to set the soul on fire with a longing for spiritual realisation. In the absence of this longing and struggle, the belief of the faithful does not differ from the unbelief of the faithless. Belief with most people is simply another name for mental laziness. Religious earnestness with people of this class means, especially when organised under a militant church or a theocratic state, either the pursuit of aggressive religious proselytism or of *jehads* and crusades. They cannot understand the meaning of that earnestness which proceeds from an inner spiritual hunger. No dogma or creed or frenzied acts can satisfy this hunger of a religious heart. Its only bread is spiritual realisation. Religion is a matter of inner experience, a coming in touch with spiritual facts, and not a matter of belief or dogma or conformity.

Strengthened by the spirit of the Upanishads, no all-powerful church, therefore, rose in India to organise the faithful on the basis of dogma and creed, and claiming divine authority for its opinions and judgements. No such authority could thrive where religion was expounded as a quest and not a conformity. A spiritual view of religion, as different from a creedal or dogmatic view, makes religion not only cultivate a spirit of toleration, questioning, and inquiry in its own sphere, but also foster it in every other department of life. The *Bhagavad Gita* (VI. 44) declares that a spirit of inquiry into the meaning of religion takes an aspirant beyond the authority of the words of scripture and mandate of tradition. He becomes an experimenter himself, instead of remaining a mere believer. Indian religious thought emphasises *sadhana*, experiment, as the dynamics of religion; it has recourse to *Jijnasa*, or inquiry, for the formulation of its views, by it *brahmajijnasa*, inquiry into the nature of Brahman, *i.e.*, God as the one Self of all *or dharmajijnasa*, inquiry into *dharma*, *i.e.*, social ethics and personal morality.

This sublime attitude to religion and thought is the fruit of the unified view of the mental life of man which India learned from her Upanishads, and which she assimilated into her mind and mood by a universal acceptance of all forms of faith and by showing due regard to all knowledge, whether sacred or secular.

9. Vidya Dadati Vinayam

Science in the modern age has lengthened man's intellectual tether, but this has only helped to bring into sharper focus the mystery of the unknown and the significance of the *para vidya* (higher knowledge or wisdom) of which the Upanishads speak. In the words of J. Arthur Thomson

(*Introduction to Science*, Home University Library edition, 1934, p. 205):

> At the end of his intellectual tether, man has never ceased to become religious.

It is no wonder, therefore, that several scientists, during the last few decades, have been forced to overstep the limits of their sciences and tackle the problem of the unknown at closer quarters in a mood of humility and reverence, illustrating the dictum of Indian wisdom : *Vidya dadati Vinayam*—'knowledge bestows humility', and the saying of Coleridge quoted by J. Arthur Thomson (*ibid.*, p. 208):

> All knowledge begins and ends with wonder ; but the first wonder is the child of ignorance ; the second wonder is the parent of adoration.

Dogmatism and cock-sureness which stifle the spirit of free inquiry are as much enemies of true science as of true religion. There are not wanting scientists today who would, taking a narrow view of the scope and function of science, prefer to go the dogmatic way and cry halt to advancing knowledge and unified experience. That way spells danger to science now, as it has spelt danger to religion before. *A greater devotion to the spirit of free inquiry and a broader conception of the aim and temper of science is our only safeguard against such a pitfall.*

If the nineteenth century was the century of conflict and division, the twentieth century bids fair to become the century of reconciliation and union, as a result of a sincere effort on the part of both science and religion to reassess itself and to understand the other. The humility of twentieth century physical science presents a sharp and welcome contrast to the cock-sureness of its nineteenth century counterpart. It has realised that the spirit of free inquiry, on which it has thrived

may find expression in fields beyond its own narrow departments, and that it is this spirit, unbiased by personal attachments and aversions, that makes a study scientific, and not the mere subject-matter of that study,

This wider view of science as a discipline and a temper enables us to class as scientific the study of the facts of the inner world which religion has set to itself for inquiry.

And this has been the Indian approach to religion. It was the absence of this approach that made religion in Europe less and less equipped to meet the challenge of advancing knowledge.

10. Limitations of Physical Science

When we go deeper into the nature and scope of physical science, its limitations become apparent. To illustrate: Two branches of science, namely, physics, including astronomy and biology, including behaviouristic psychology, have given us a vast body of knowledge regarding the nature of the universe and man. Up to the end of the nineteenth century, physics was warped in its final judgements. It saw materialism and mechanism reigning supreme in the universe. There was then a cock-sureness in its pronouncements; but, in the twentieth century, an element of humility is discernible in the attitude of the great physicists of the age. In the nineteenth century, knowledge of the physical world was not deep enough, and scientists looked only at the surface of things. But, along with the discovery of such facts as radio-activity and insight into the nucleus of the atom, the realisation has come that there is a severe limitation placed on our knowledge regarding the truth of the external world. Science owns today that it deals only with *the appearances of things* and not with *the reality behind these appearances.* Some of the greatest of modern physicists tell us that what science has revealed of the

world around us is only the outer aspect of things. Behind this *observable* universe, there is an *unobservable* universe, as well as the *observer* himself. This is a great confession of the limitations of science and its methods. Science is dealing with phenomena revealed by the senses or by apparatuses helpful to the senses. But these senses reveal so little, and what they reveal only tells us that there are realities behind the sense world determining it and controlling it. Physical science restricts itself to the understanding of the observable part of the universe and to controlling its energies for the use of man.

A similar situation obtains in the science of biology. In the last century, it was cock-sure about its pronouncements. By a study of the different aspects of the phenomena of life, it arrived at the great theory of evolution, from which it drew certain conclusions influenced by the mechanistic materialism of contemporary physics, which directly led to a form of materialism, that equated man with the animal, and both to a machine. Today, scientists tell us that they were not happy titles that Darwin chose for his famous books: *The Origin of Species* and *The Descent of Man*. Sir Julian Huxley suggests that these could have been more appropriately titled: *The Evolution of Organisms* and *Ascent of Man* (*Evolution after Darwin*, Vol. I, The University of Chicago Press, p. 17). But, then, these books appeared at a time when a fierce controversy was going on between emerging science and the entrenched Christian dogma of supernaturalism upholding man as a special creation of an extra-cosmic God, and this had its impact even on the choosing of the titles of great scientific books. The science of physics with its thorough-going materialism and mechanistic determinism, and the science of biology with its newly discovered evolutionary theory and its domination by the general materialistic outlook of science

and scientists of the age, helped to shatter nineteenth century man's faith in that view of religion and spiritual values which was presented to the West as supernatural and anti-science.

11. Kinship between Ancient Vedanta and Modern Science

Swami Vivekananda has shown that religion, as developed in India in her Vedanta, and modern science are close to each other in spirit and temper and objectives. Both are spiritual disciplines. Even in the cosmology of the physical universe, in the theory of the unity of cause and effect, in the unity and conservation of matter and energy, and in the concept of evolution, cosmic and organic, the two reveal many points of contact. Unlike as in the *super*-naturalistic theologies of the West, the fundamental position in the cosmology of both Vedanta and modern science is, what Swami Vivekananda calls, 'the postulate (of the ultimate reality) of a self-evolving cause'. Vedanta calls it Brahman, which is a universal spiritual principle. The *Taittiriya Upanishad* (III. 1) defines Brahman in a majestic utterance, which will be welcomed by every scientific thinker:

Yato va imani bhutani jayante, yena jatani jivanti ;
yat prayantyabhisamvisanti ; tad vijijnasava : tad brahmeti—

'Wherefrom all these entities are born, by which, being born, they abide ; into which, at the time of dissolution, they enter—seek to know That ; That is Brahman.'

To the modern scientist, that self-evolving cause is a material reality, the *background material* or *cosmic dust*, as astrophysicist Fred Hoyle terms it ; whereas, to Vedanta, which views it also in the light of the consciousness revealed in its evolutionary product, namely, man, it is a universal spiritual principle, the *cit akasa*.

Referring to this spiritual kinship between modern science and ancient Vedanta, Swami Vivekananda said in his speech at the Parliament of Religions held at Chicago in 1893 (*Complete Works*, Vol. I, eleventh edition, p. 15) :

> Manifestation, and not creation, is the word of science today, and the Hindu is only glad that what he has been cherishing in his bosom for ages is going to be taught in more forcible language and with further light, from the latest conclusions of science.

Although modern scientific thought does not yet have, like Vedanta, a recognised place for any spiritual reality or principle, several scientists of the twentieth century, including biologists like Teilhard de Chardin and Sir Julian Huxley, as pointed out earlier, have endeavoured to soften the materialism of physical science and to find a place for spiritual experience in the scientific world picture. Even Thomas Huxley, as quoted earlier, had termed materialism *an intruder*. In this century, this protest has come from great physicists also. Sir James Jeans found that the final picture of the universe emerging from twentieth century physical science was one in which the notion of matter was completely eliminated, 'mind reigning supreme and alone' (*The New Background of Science*, p. 307). Astrophysicist R. A. Millikan considered materialism 'a philosophy of unintelligence' (*An Autobiography*, last chapter).

12. Philosophy : Synthesis of Science and Religion

If twentieth century physics is thus turning its face away from thorough-going materialism, twentieth century biology is one step ahead of it in this orientation. The whole of modern scientific thought is in the throes of a silent spiritual revolution with the emergence, on the horizon of scientific thought, of the challenge of mind and consciousness, and the

consequent need to develop, what Jeans terms *a new background of science* in the light of what he says further (*ibid.*, pp. 2-6):

> The old philosophy ceased to work at the end of the nineteenth century, and the twentieth century physicist is hammering out a new philosophy for himself. Its essence is that he no longer sees nature as something entirely distinct from himself. Sometimes, it is what he himself creates or selects or abstracts; sometimes, it is what he destroys.
>
> Thus the history of physical science in the twentieth century is one of a progressive emancipation from the purely human angle of vision.

Julian Huxley and Chardin find the spiritual character of the world-stuff successively revealed in the course of organic evolution. Biology, in its theory of evolution, they hold, reveals what Chardin calls *a within* to nature, over and above and different from *the without* of nature revealed by physics and astronomy. Vedanta terms the 'within' as the *pratyak rupa* and the 'without' as the *parak rupa* of one and the same nature. When the significance of this *within* of things is recognised in modern science, the scientific 'background material' will undergo a spiritual orientation and thus come closer to Brahman, the 'background reality' of Vedanta. The synthesis of the knowledge of the within and the without is philosophy; and this was what India achieved in her Vedanta ages ago as *samyak-jnana*, comprehensive or perfect knowledge of total Reality. Reality itself does not know any distinction between a within and a without. These distinctions are made only by the human mind for the convenience of study and research and daily life.

As the different branches of the physical sciences are but different approaches to the study of one and the same reality, namely, physical nature, and as all such branches of study,

when pursued far enough, tend to mingle and merge into a grand science of the physical universe, *into a unified science of the 'without' of nature*, so the science of the 'within' and the science of the 'without' mingle and merge in a science of Brahman, the total Reality. This is how Vedanta viewed its *Brahmavidya*, science of Brahman, the term Brahman standing for the totality of Reality, physical and non-physical; the *Mundaka Upanishad* (I.i.1) defines *Brahmavidya* as *sarva-vidya-pratishtha*, the *pratishtha*, or basis, of every *vidya*, or science. Says Sri Krishna in the *Gita* (XIII. 2):

Kshetra-kshetrajnayor jnanam yat tat jnanam matam mama—'The knowledge of *kshetra*, the not-self (the 'without' of things), and of *kshetrajna*, the knower of the not-self (the 'within' of things), is true knowledge according to Me.'

Dealing with the all-inclusiveness of this Vedantic thought as expounded by Swami Vivekananda, Romain Rolland says (*The Life of Vivekananda*, p. 289):

> But it is a matter of indifference to the calm pride of him who deems himself the stronger whether science accepts free Religion, in Vivekananda's sense of the term, or not; for his Religion accepts Science. It is vast enough to find a place at its table for all loyal seekers after truth.

In his lecture on 'The Absolute and Manifestation' delivered in London in 1896, Swami Vivekananda said (*Complete Works*, Vol. II, ninth edition, p. 140):

> Do you not see whither science is tending? The Hindu nation proceeded through the study of the mind, through metaphysics and logic. The European nations start from external nature, and now they, too, are coming to the same results. We find that, searching through the mind, we at last come to that Oneness, that universal One, the internal Soul of everything, the essence and reality of everything... Through material science, we come to the same Oneness.

13. India and the Scientific Approach to Religion

The methods of investigation in the field of religion are largely the same as in the positive sciences. Collection of facts, their classification, a dispassionate study of these so as to reveal the law or laws underlying them, such knowledge leading to the control over the phenomena concerned, and, finally, the application of such knowledge for the technique of man's spiritual growth, for the alleviation of human suffering, and for the enrichment and fulfilment of human life. This kind of study of religion, as a thorough scientific study of the facts of the inner life, was undertaken by the great sages of ancient India; the insights which they gained were re-tested and amplified by a galaxy of subsequent sages, leaving to posterity the invaluable legacy of a rich and dynamic scientific tradition in the field of religion. *It is because of this adamantine rational and experiential base that Indian spirituality has stood the test of time. That also explains its hospitality to modern physical science, and its pride in the remarkable achievements of this sister discipline developed by the modern West.*

Says Romain Rolland about this quality of Indian philosophical thought (*The Life of Vivekananda*, p. 196):

> The true Vedantic spirit does not start out with a system of preconceived ideas. It possesses absolute liberty and unrivalled courage among religions with regard to the facts to be observed and the diverse hypotheses it has laid down for their coordination. Never having been hampered by a priestly order, each man has been entirely free to search wherever he pleased for the spiritual explanation of the spectacle of the universe.

After a thorough investigation into the real nature of man, the sages of Upanishads made a fundamental discovery: man, in his essential nature, is divine; behind the finite man is the Atman, ever free, ever pure, and ever

perfect. The body, the mind, and the ego are merely the externals of the real man who is immortal and divine. This discovery led to the further discovery that the same divinity is the ground of the world as well. This they termed Brahman, the totality of the Self and the non-Self, which they characterised as *satyam jnanam anantam*—'Truth, Consciousness, and Infinity.'

14. Science and Religion Complementary

Religion expounded as a verified and verifiable science has a message for all humanity. Physical science, through its technology, may build for man a first class house, and equip it with radio, television, and other gadgets; the social security measures of a modern welfare state may provide him with everything necessary for a happy fulfilled life in this world, and even, through the state church, in the world beyond; the man himself may give his house such arresting names as *Shanti Kunj* (Peace Retreat) or Sukha Vilas (Happy Home). Yet none of these can ensure, by themselves, that he will live in that house in peace or happiness. For that depends, to a large extent, on another source of strength and nourishment, another type of knowledge and discipline—the knowledge and discipline proceeding from the science and technique of religion. If man can have the help of the positive sciences to create a healthy external environment, and the help of the science of spirituality to create a healthy internal environment, he can hope to achieve total life-fulfilment; not otherwise. This is the view of the Upanishads.

But, today, this is not the picture that modern civilisation presents. Man in this technological civilisation is feeling inwardly impoverished and empty in an environment of wealth, power, and pleasure; he is full of tension and sorrow, doubt and uncertainty, all the time. Juvenile delinquency,

drunkenness, suicide, and a variety of other maladies are ever on the increase. Why? Because man is not inwardly satisfied: he is smitten with ennui and boredom arising from the limitations of his sense-bound *Weltanschauung*. Indian thinkers foresaw this predicament of modern man ages ago. Says the ancient *Svetasvatara Upanishad* about the modern space age (VI. 20):

> *Yada carmavad akasam vestayisyanti manavah :*
> *Tada devam avijnaya duhkhasyanto bhavisyati—*

'Even though men may (through their technical skill) roll up space like a piece of leather, still there will be no end of sorrow for them without the realisation of the luminous One within.

Schopenhauer said a hundred years ago (*The World as Will and Idea*, Vol. I, p, 404):

> All men who are secure from want and care, now that at last tehy have thrown off all other burdens, become a burden to themselves.

15. Religion is Realisation

Today, man is his own major burden and problem. He can tackle and solve this problem, not just by going in for more positivistic science, more technology, more life's amenities, more socio-political or micro-biological manipulations of human conditions, but by the cultivation of the science of religion. Says Swami Vivekananda (*Complete Works*, Vol. IV, eighth edition, p. 35):

> You must bear in mind that religion does not consist in talk, or doctrines, or books but in realisation; it is not learning, but being.

It is in this sense that India understood religion: and it is this idea of religion that Swami Vivekananda expounded in the West and the East through his powerful voice. The end and aim of religion, as our ancient teachers put it, is the

experience, *anubhava*, of God, through the steady growth in man's spiritual awareness. That is the touchstone of religion. There is such a thing as the *spiritual growth* of the individual, step by step. We experience this growth, just as we see a plant growing, or a building rising up step by step, brick by brick. When we live the life of religion, strength comes to us, consciousness becomes enlarged, sympathies grow and widen, and we feel that we are growing into better men. It is only the strength that proceeds from such inward growth and development that will enable man to digest and assimilate the energies released by the progress of scientific technology. Such a man alone has the strength and wisdom to convert the chaos of life into a pattern of happiness and general welfare. If religion is taken away from human society, what remains is simple barbarism. Ancient civilisations were destroyed by barbarians bred outside those civilisations. But modern civilisation, if it is to go the same way, will be destroyed by barbarians bred within the civilisation itself. What can save us from this predicament is a little 'Christian love' in our hearts for our neighbours, in the words of the late Bertrand Russell (*Impact of Science on Society*, p. 114), or a little more altruism, in the words of Pitirim A. Sorokin of Harvard University (*Reconstruction of Humanity*, especially Part V). This love comes from the practice of religion, as defined by the world's authentic spiritual teachers. Says Vivekananda giving a scientific definition of religion (*Complete Works*, Vol. IV, eighth edition, p. 358) :

> Religion is the manifestation of the divinity already in man.

Now comes the question, 'Can religion really accomplish anything'? asked Swami Vivekananda, and proceeded to answer (*ibid.*, Vol. III, eighth edition, p. 4) :

> It can. It brings to man eternal life. It has made man what he is and will make of this human animal a god. That

> is what religion can do. Take religion from human society and what will remain? Nothing but a forest of brutes. Sense-happiness is not the goal of humanity. Wisdom, *jnana*, is the goal of all life. We find that man enjoys his intellect more than an animal enjoys its senses; and we see that man enjoys his spiritual nature even more than his rational nature. So the highest wisdom must be this spiritual knowledge. With this knowledge will come bliss.

16. Need for a Synthesis of Science and Religion in Education

Education has to enable all students to achieve at least a fraction of the synthesis of East and West, spirituality and science, contemplation and action. It is the science of spirituality, the *para-vidya*, the supreme science, that fosters in man ethical, aesthetic, and spiritual values, including the moral values associated with pure science. The harmony of all these values, and the intrinsic harmony between science and religion, always upheld in Vedanta, became revealed in our time in the deep spiritual kinship between Narendra, the representative of *apara-vidya*, and Sri Ramakrishna, the full embodiment of *para-vidya*. All such values emerge from out of the depths of the human spirit at a certain stage of evolution and after the achievement of some measure of mastery of the environment by man; they do not emerge from physical nature itself. It is folly, therefore, to believe or to expect that they will automatically result from industry or from technological manipulations of external nature, and from the wealth resulting from such achievements. Protesting against such widely held modern folly, the late Bertrand Russell said (*Impact of Science on Society*, p. 77):

> The machine as an object of adoration is the modern form of Satan, and its worship is the modern diabolism...
> Whatever else may be mechanical, values are not, and this is something which no political philosopher must forget.

It is thus obvious that, if the current secular school and university education is high and higher education, spiritual education that Swami Vivekananda received from Sri Ramakrishna in our times, bearing the wonderful fruits of character, deep as the ocean and broad as the skies, and harmonising East and West, religion and science, the sacred and the secular, is the highest education into which the other two, to fulfil themselves, must lead a child. Sri Ramakrishna's experience and example also make it clear that man can enter into, and benefit from, this spiritual education from any stage or level of his school or college education. Wisdom can accompany, and enliven, and creatively stimulate, knowledge at any level—primary or secondary, under-graduate or post-graduate. It is also equally clear that, without a little of that wisdom, knowledge at any of these levels can become, in the long run, not a blessing but a curse to oneself and to society, a breeding ground of pride, selfishness, exploitation, and violence, on the one hand, and alienation, loneliness, and psychic breakdowns, on the other. These have afflicted societies and civilisations in the past, and led them to decay and death. And modern Western civilisation is also facing that challenge today. As our own country also is absorbing the energies of this modern civilisation at a fast pace today, and is already experiencing some of its distortions, we shall be wise if we open ourselves up also to the eternal message of our *adhyatma-vidya*, or science of man in depth, and generate a fresh capital of our spiritual energy resources, with a view to digesting, assimilating and transforming the physical and mental energy resources of our highly technical age.

17. Science and Religion versus Magic and Miracles

Some of our people, especially among our educated sections, including our administrative personnel run after

all sorts of magic and miracles, puerile and sterile, in the name of religion and *yoga*. In this age of the marvels of physical science, such religious magic and miracles appear infantile. What magic and miracles, performed in the name of a cheap religion and *yoga*, and held in secret by the performers, can compare with the 'miracles' performed by the physical sciences, *verified* and *verifiable*, *open* and *communicable*, whether in the field of curing of diseases, and that too on a mass scale, *increasing of food production*, or putting a man or a vehicle on the Moon or the Mars and bringing both back to earth! The great Buddha discouraged all miracles and secrecy in religion. What is secret may not be sacred. What is sacred need not be secret. His teachings were profound, but open, *ehi passa, ehi passa*, 'come and see, come and see', as he picturesquely expressed it. Addressing his disciple Ananda, he said: The Tathagata has no secrecy; secrecy belongs to three things, O Ananda: to priestly wisdom, to false knowledge, and to prostitutes.

It is imperative that our people turn away from the cheap and *secret* miracles of *yoga* and religion, indulgence in which had kept our people weak and superstitious and in political slavery for centuries, and turn to master the marvellous and *open* miracles of physical science for our individual and collective welfare.

The only 'miracle' that can match, and also over-match, the great miracles of modern physical sciences is the 'miracle' of character produced by pure religion, by the science of spirituality. Purity, love, compassion, work-efficiency, dedication, and service—these are the wonderful fruits which are produced by the science of religion in us. Gandhiji wrought, and taught, the miracles of transmuting hatred into love and violence into non-violence.

Dependence on the cheap miracles of religion and *yoga* weakens the human mind; *they are hypnotic in their effects.* Vedanta and all the great spiritual teachers of the world, therefore, never encouraged them. Vivekananda preached Vedanta to *de-hypnotise* such and other already hypnotised people in the East and the West; 'Strength, Strength, is what the Upanishads preach to me from every page', he proclaimed. He preferred people becoming atheistic and agnostic to becoming superstitious fools; for the atheist and the agnostic, he said, can still attain freedom, but not those who are weakened by superstition. That is why Sri Krishna preached *buddhi-yoga,* the *yoga* of Reason, as the unfailing guide in life, in the great *Gita.*

Vedanta has provided the science of religion with an intelligible and international framework of terms and concepts which help the various religions of the world to understand themselves, to understand and welcome each other, and to understand and appreciate the physical sciences. This is precisely the service that modern physical science has rendered to all physical or positivistic knowledge. Both thus become, though developed in different countries and in different periods of history, human contributions to knowledge and life fulfilment.

18. Conclusion

Understood in this light, there is no conflict between science and religion. Both have the identical aim of discovering truth and helping man to grow physically, mentally, and spiritually, and achieve fulfilment. But each by itself is insufficient and helpless. They have been tried separately with unsatisfactory results. The older civilisations took guidance mostly from religion; their achievements were partial and limited. Modern civilisation relies solely on science;

its achievements also have turned out to be partial and limited. The combination today of the spiritual energies of these two complementary disciplines in the life of man will produce fully integrated human beings, and thus help to evolve a complete human civilisation for which the world is ripe and waiting. This is the most outstanding contribution of Swami Vivekananda to human thought today. This synthetic vision of his finds lucid expression in a brief but comprehensive testament of his Vedantic conviction (*Complete Works*, Vol. I, eleventh edition, p. 124; words in brackets not by Vivekananda):

> Each soul is potentially divine.
> The goal is to manifest this divine within by controlling nature, external (through physical sciences, technology, and socio-political processes) and internal (through ethical, aesthetic, and religious processes).
>
> Do this either by work, or worship, or psychic control, or philosophy—by one, or more, or all of these—and be free. This is the whole of religion. Doctrines, or dogmas, or rituals, or books, or temples, or forms, are but secondary details.

Science and Society

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Introduction

Modern society is the greatest patron and the greatest benefactor of science. The majority of all the world's scientists and technologists from the beginning of recorded history are alive today, in no small measure, due to the steady and generous support given to these endeavours. On the other hand the functioning of a modern industrial society is unthinkable without the tremendous gains derived from and steadily being contributed by science and technology. While much remains to be done to eradicate poverty and misery and to establish social justice and equal protection of the law throughout the modern world, science and technology are helping in furthering these aims of mankind.

In such a partnership between scientists (and technologists) on the one hand and society on the other, there are inevitably questions of the role and scope of the mutual relationships and of the nature of the social contract. As the nations of the world become more aware of the importance of science in relation to society the question of the obligations and duties of scientists and social control of scientific programmes comes increasingly to the fore. Many people of wisdom have devoted much thought to these questions.

The following paragraphs present one person's understanding and findings; he has benefited from conversations with many of his colleagues at the Centre for Theoretical Studies, Indian Institute of Science, Bangalore, and elsewhere.

Scientist as a Citizen

Having been a scientist and having moved among scientists it is natural for me to see scientists as citizens, as human beings. While this seems quite obvious to me, I am often amazed by the caricatures drawn of the scientist as a humourless, insensitive person unmindful of his obligation to society and unwilling to participate in the social adventure. Often we come across people, sometimes well intentioned and good people, who exhort us to be patriotic and involved, be humanistic in our outlook and interested in communication with the masses: as if, by being scientists we have ceased to be ordinary citizens.

Like any other person who functions within society, the scientist too is bound by a social contract; and as such, a certain degree of professional competence and performance is expected of the scientist. Amongst themselves the scientists develop and foster a notion of professional ethics, a code of conduct. This self-referring self-correcting framework is the framework necessary for an organized scientific endeavour. To the extent that scientists of any nation lack this framework, to that extent the scientific endeavour is enfeebled.

Among scientists one often includes students and teachers of science, researchers on the frontiers of knowledge, expositors and propagandists of science including science writers and persons who influence science policy. In all these categories are people who have chosen science and whom science has chosen. But there are also others who took on science as a "civil service", as a living. In the sequel

I shall ignore these people more or less but include others whose outlook is scientific but whose pursuits are not formally identified as scientific.

What is the nature of the interaction between scientists and society? What is the science-society nexus? Scientist grows up in society, is provided his general and specialized education and later on receives continuing support and recognition by society. Society provides the environment in which science can grow and come to fruition. He gets a chance to "hob-nob with fellow wizards". In return scientists do skilled work for society. Many of them work very hard and do it with wisdom, concern and dedication.

But the scientist should be given "special handling" if he is to function best. A certain specialized environment has to be provided, special loving care, of the kind that one would give to a costly scientific instrument. Not because the scientist is an instrument but because it is important that scientific work must proceed most efficiently. This is a two-way street: society provides a specialised environment for the scientist to work, but in return the scientist furnishes work done with devotion going beyond the call of duty.

Scientist as a Participating Observer

In the context of the mutual relationship between scientist and society we are led to ask about the role of the scientist as a leader versus his role as a follower: his role as a builder versus his role as a critic. What is the society to which he responds?

He who investigates the motions of celestial bodies and of subatomic particles, of biosphere and of self-replicating biomolecules should not be expected to accept a picture of society and its workings that is given to him from outside.

There was a time when the heavenly firmament was supposed to be set in a crystal framework or when the circumference of a circle was taken to be precisely thrice its diameter; there was a time when women "did not have souls" and one man was considered to be superior or inferior to another by virtue of birth alone. There was a time in which the earth was the immovable centre of a universe. We have abandoned these views as incorrect or irrelevant and found better perspectives, more satisfactory models today. The scientific theories of a hundred years ago appear amusing to us now in many cases. That applies to social theories as well.

In many cases the new view-points make it easier to comprehend and compute. Instead of an earth-centred solar system with its epicycles we find it more satisfying to employ a sun-centred solar system in which planetary orbits are practically circular. This is not to say that one does not deal with the earth in everyday life as terra firma.

So also with the scientist in relation to society. Most of the time he goes along with the picture adopted by the contemporary culture. But when a particularly important question of principle is involved he is apt to employ the analytical perception he employs in his scientific endeavour. He may ask you: What is the society to which I respond? What is the structure of the society and what principles govern its dynamics? Is our view of society a satisfactory one, one that could enable us to function more efficiently?

It appears to me, by and large, scientists should continue to perceive the society as a dynamical system and try to discern the forces that move society, study the model so obtained and improve on it as he goes on. But in everyday life he accepts the societal obligations as he finds them; to this

extent he must limit his natural critical faculty and his individual freedom.

These twin roles of being a member of society and at the same time acting as an observer of society require considerable flexibility and integrity from the scientist. The observing scientist perceives society as a dynamical system and the forces he sees may not be acknowledged by society at large. Nevertheless as a scientist, as a person of integrity, has to move in a direction which is contrary to the expressed dictates of the society to a certain extent. Any deviation from the mores of society will automatically mean that society will tend to bring the scientist back to the views held currently by that society. We may compare this with the situation of a spring which has a standard equilibrium position; any departure from this is resisted by elastic forces, but a persistent force can create a new equilibrium position. The work done in this alteration is not lost but stored as "potential energy" in the spring, ready to be converted into energy of motion under suitable circumstances. So also with the scientist. The altered position that he maintains, if and when he does it, is one maintained by a conviction and this position carries with it the potential for movement for the benefit of society. Like the extra effort needed in picking a suit-case for a long journey, a scientist should strain against the restrictions imposed by society if in his heart he knows it to be the proper thing to do, but do it only to the extent that it can be done without causing rupture.

To illustrate this let us consider the contemporary ideas on democracy and equality before the law. It is the simplest hypothesis to make that in the absence of specific contrary knowledge all people are equal; and, therefore, everyone must have equal opportunities. Everyone should have the right to look for happiness and well-being, to make use of the

riches and facilities of the nation. But is it the same thing as saying that everybody *is* equal or should be *made* equal? The physical scientist is apt to look for a physical model for comparison. Consider a fluid made up of a collection of interacting molecules. For simplicity one may consider a dilute gas made up of identical molecules which go about their own ways but often colliding with other molecules. The molecules are identical and therefore they all have the same access to the total energy of the gas but do they all have the same energy? They do not, at any time, have the same energy. For a dilute gas we know that the energy is distributed in a non-uniform fashion given by the "Maxwell distribution" which corresponds to a bell-shaped distribution function. The probable value of the energy is close to the energy shared equally, but some molecules have much larger energy and some have much smaller energy. This is the natural state of affairs. If we deliberately worked hard to have strictly equal energies for all the particles, in a short time by interaction and exchange of energy between them the molecules would re-establish their distribution. It is idle to lament over this inequity in the distribution of "wealth".

Does this mean that we must always and under all conditions look for such a distribution? The answer is clearly negative. If we want the fluid to flow along a tube we must not be content to have all directions of velocities equally probable; we must arrange for a preference for velocities in a particular direction. We may make use of an aspirator or some other form of a pressure differential to induce them to behave thus.

The scientist should thus perceive the dynamic nature of society and discern the laws and constraints operating on the functioning of the individual. If he is convinced that the forces are not bringing about the desired results he should

search for and bring into action other forces that could bring about a more efficient society. But throughout it all he must remember that while he sees the society as a dynamical system he is a member of it.

Freedom and Constraint : Scientist as Rishi

In treating society as a dynamical system while remaining a member of it, the scientist is aware of both freedom and constraint. In observing the nation as a functioning unit, the international scene in terms of its dynamics rather than its mottoes and even the society of scientists, the individual scientist is painfully aware of restrictions that hinder movement. But this is only one stage of seeing : when he observes movement, causes of motion and the underlying structure of the dynamics, he sees things as they really are. He sees that it is movement under constraints which generates forms, new modes of motion. Structure and form are the children of freedom and restrictions. If you had a flute with no bamboo or no holes it would cease to be a flute ; if you had a veena whose strings were not held taut, it could make no music. It is only when you have both movement and constraints on that movement that a structure can evolve. If you had freedom with no restrictions at all, then movement would be completely arbitrary ; if you had no freedom and all restriction, movement would be killed.

The perceptive scientist, then, sees the dual structure of freedom and constraint as natural order, as the generator of form and structure ; and ultimately as two aspects of the modality of functioning.

Not only in his functioning within society but also in his own spiritual search does the scientist encounter this situation. In fact the spiritual path may be identified as a search for

synthesis between the perspective in which individual will is paramount and the perspective in which everything is predetermined. If everything is predetermined whether in personal life or in society there are no concerns and no cause for anxiety. If, on the other hand, we are free to do whatever we wished to do, then also there is no cause for anxiety. But we find that neither is a correct appraisal: we are both free and constrained. Frustration comes when we anticipate freedom and find constraints; and confusion when we anticipate constraint, a set of rules or some wise leader telling us what to do, and find that we are on our own. Both situations are unsatisfying; both are partial views.

The scientist finds himself more often in the latter predicament of having too much freedom and too little guidance and less often straining against the bit. This has a curious side-effect. Often, we find groups of scientists furiously pursuing the task of defining social goals and norms well beyond their normal realm of interest and flogging themselves to carry out these self-imposed strictures. For example we find university faculty members getting passionately involved in such matters as curriculum revisions, participation in national defence-related research, preservation of an obscure biological species at all costs, settling questions of international diplomacy and so on. We now find renewed awareness of the village basis of our society and so a large number of scientists in our country are involved in village technology, gober gas, bullock cart and so on. All these are legitimate pursuits and as relevant as discipline for a monk. But when this concern becomes pathological, in that it becomes a constraint on all; and like all excesses when it leads to the stifling of genuine creative scientific effort through excessive zeal and preoccupation with an isolated

item to the detriment of its basic functioning, it is bizarre. It is like flagellation by a monk in pursuit of discipline. Freedom is not indulgence any more than the attempt to discover the fundamental laws governing matter may be viewed as indulgence; nor is it intolerable to have laws and constraints any more than to have the law of gravity or the laws of electromagnetism intolerable!

The resolution to this issue of freedom versus constraints is the dawning of insight. Insight transforms the structure in terms of freedom and constraint into a complete and integrated system in which anxiety is replaced by knowledge. Transcendence is, therefore, not a negation of freedom nor is it submission to the inevitable. It is a recognition and conviction that both these are complementary aspects of a unified structure. Instead of seeing double vision and seeing two views, we get binocular vision and "depth" to the field of view. We do not see the flute as freedom and as obstruction: it is the integrated structure that is the flute, and that is what generates melodious sounds. Right perception brings about efficiency, and, through efficiency, it brings mastery.

We say that a person has attained mastery, when he is able to function within the context of the constraints with ease, as if he is completely free. A talented musician has superb control over her voice and the sequence of ragas and yet appears to do so effortlessly. A dancer or a tennis player appears to function without appearing to make the effort. In all these cases one recognizes the forces and patterns of the system and by judicious use of effort bring about the natural result. In other words, nature is taken on as an ally rather than as an adversary.

This, then, is the proper relationship between scientist and society. The scientist perceives the dynamics with its attendant freedom and constraints, laws and options. He

policy also, in the same manner, involves several levels At one level we must decide whether a certain area is to be pursued. But at another level we concern ourselves with how best to pursue it.

Our universities suffer even more acutely from interference in scientific pursuits. The responsibility of the state governments and local society, of the national government or political leaders certainly involves concern for the well-being of the scientists and the share of resources to be allocated for science in the universities ; but equally definitely it does not warrant interference in the details of this pursuit In Malayalam there is a saying to the effect that if you want a cannon to shoot properly, you should not get inside it. but stay outside and light the fuse !

We often see, as another facet of this state of affairs, the confusion of science with technology. Technology is the application of scientific principles in relation to technical and industrial problems. The fruits of technology are many and are essential to the functioning of society. And the frontiers of technology are much more visible and vivid in contrast to the advancing frontier of science. Most of the time out of confusion, though perhaps sometimes as deliberate misrepresentation, one tends to cite technological artefacts as the achievements of science. We talked earlier of potential energy versus kinetic energy. The second one, the energy of motion, is easily seen and appreciated. But the first one, the energy of configuration is just as real and can be converted into kinetic energy. The relationship between science and technology is also similar. Scientific discoveries are potential wealth of the nation and are real assets ; they may be converted into movement of industry and agriculture and then they are seen as technological progress. But to view only the latter and not the former is to disregard the roots

and consider only the shoots. Technology without a science base is like a collection of cut flowers. Sometimes one has to use cut flowers, but one hopes that a garden of flowers can be made to grow up as soon as possible rather than keep on buying cut flowers.

Yet another misidentification is science administration with science. Science administration is very important and cannot be entrusted to just anyone. Just as an engine driver is to be a skilled person, a science administrator has to be skilled. But it would be silly to consider the engine driver to be the purpose for the train and the passengers to be his followers. So, too, with science. Very often science administrators are scientists of more or less demonstrated ability, but functioning as an administrator should not be interpreted as making him or her a greater scientist. Nor is it true that a better scientist is a better science administrator: sometimes quite the contrary is the case. In the context of the rapidly expanding support for science, the science managers have done very important and commendable work. But as the body of scientists acquires maturity and self-reliance, wisdom and insight, these understandable confusions will gradually dissipate.

Before leaving this topic we must also allude to another confusion. Since science goes forth discarding, testing, strengthening, and searching much of it is new. Traditional knowledge in some of these areas is tantamount to discredited knowledge. This does not, however, mean that science is opposed to traditional knowledge. Quite the contrary, in fact: when one understands the basic principles of some branch or other of science, they resonate in an uncanny manner with traditional knowledge and sacred texts. If the student of molecular biology finds the opening verse of the Gospel of St. John, or the student of quantum field theory

finds certain verses in the Bhagavat Gita relevant, one should not be anxious to disregard these correspondences. The Sufi masters, or the Rishis of Rig Veda sound extremely modern with regard to the study of altered states of consciousness. As long as one does not get into the position of maintaining that all scientific discoveries are contained in traditional knowledge, there need be no opposition between traditional knowledge and scientific knowledge. One does not have to give up one's cultural moorings to become scientific!

Science as Society's Path to Fulfilment

The resolution of the predicament of the scientist as observer-critic and member of society in itself, also gives the best answer to "Why science"? When faced with laws and constraints and freedom to act as well, the wise man attempts to comprehend the laws fully so that he may use his limited freedom efficiently. He becomes an adept. This passage from insight to adepthood frees much of one's initiative to truly creative pursuits.

Man is born to be happy. Disharmony comes from disarray, from misunderstanding. As one understands the nature of one's existence and functions efficiently within it, one's creative energies are freed. The routine things that are to be done no longer absorb one's attention. When you first learn a language, you devote much time to syntax and grammar, idiom and vocabulary. But as your command increases and you become well-versed in the language, these are taken care of automatically and the real task of language, the communication of ideas, can get all the attention. Even the limitations of language no longer are bars. The great teachers amongst us always find simple language to communicate profound ideas.

So, too, in the biological world we find that as an organism evolves, it reaches the stage when homeostasis is an involuntary function. Instead of attending to the details of immediate existence, the system is enabled to expend its energies in other directions. The spiritual path is the second level of homeostasis in which one achieves the status of a "sthita prajna", one who sees the world as it is without trepidation and without frustration. Constraint and freedom are now no longer seen separately, nor are value judgments placed on natural laws. Functioning becomes efficient and spontaneity becomes the rule.

Society, too, can be considered as an organism. Subject to stimuli and yielding responses, adjusting its function to the situation in which it finds itself, it too is functioning as an organism. Civilization is the first stage of homeostasis, like the passage from simpler organisms to a warm-blooded animal. But there is a next stage where spontaneity is the dominant modality. That comes when freedom and constraint are integrated, when tradition and discoveries are seen as not in opposition. In this society scientists would function efficiently and almost everyone would function in the scientific mode.

It seems to me this is human destiny and, to the extent that it is being accelerated, science is fulfilling itself.

Science and Population Control

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Many of our problems arise largely from the lack of application of available science and technology, and much of our misery could be avoided if we would cultivate a scientific and rational outlook. There is no such thing as ethics of science. Science and technology are at best tools and instruments ; they are amoral and can be used either for the benefit or detriment of mankind.

Our population problem is the result of our population explosion which is the result of the application of science and technology. Public health and sanitation, nutrition and wonder drugs, and in general the application of modern laws of health sciences have been responsible for the dramatic and definitive decline of the nation's death rate. Once upon a time high birth rates were cancelled by high death rates. but with the help of science we have brought down our high death rate successfully but left the birth rate untouched. Hence the extraordinary multiplication of population. It is obvious that we should now apply science and technology to the control of the birth rate. Otherwise, the old balancing between births and deaths may come into existence whether we like it or not.

In a word, we cannot have a twentieth century death rate and a seventeenth century birth rate. Science here has

given us a variety of family planning techniques and the only problem is to persuade the people to adopt them so that we can stabilise our population at some manageable and reasonable figure to assure a decent level of living to every man, woman and child in our country.

What is the nature and magnitude of our population problem? Of the two major problems confronting man in the last quarter of the twentieth century, the threat of world conflict, nuclear or conventional, and the current global population explosion, the latter is perhaps more grave and disturbing in the long run. While a world war, even a thermo-nuclear one, is a one time phenomenon, even if it destroys much of the world, man's uncontrolled fertility and the millions of babies added every year to the total population in various regions, nations and the world as a whole is the greatest single man–man barrier in the path of overall planned economic and social development and the achievement of a harmonious ecological balance between man and his total environment.

The economic, social and political consequences of this incredible exponential growth is tragically familiar in the contemporary world. Who has not heard of precious earth being washed down the hill slopes into the sea, destroying the biologically pulsating top soil that takes decades and even centuries to build; the indiscriminate felling of trees and the dwindling valuable forest resources leading to a serious disturbance of the hydrological cycle and falling water tables; the rapid depletion of coal, oil and other minerals, and the exploitation of every other non-renewable resource to a point of near exhaustion.

All this is simply the result of mankind's orgy of sexual irresponsibility in multiplying like lemmings and making

infinite demands on the planet's finite resources. While the developing countries are multiplying today considerably faster than the advanced, developed and rich world, it is the latter which has in the past (and continues to today) consumed disproportionately large shares of the world's resources. The developed countries have not only exploited the human resources of the Third World in the past through conquest, colonialism, imperialism and even extermination of certain so-called primitive people, but they continue to exploit the natural resources of the land and the seas with the aid of their superior technology for their own consumption, leaving relatively little for the Third World.

And of the Third World, nowhere is the pressure of growing numbers on the available resources greater than in contemporary India, which continues to be the *locus classicus* of the Malthusian dilemma. Our country, in a word, is a classical example of endless, unlimited needs competing for severely limited resources.

The growth of India's population from the earliest times to the present, from such meagre evidence as is available, is not unlike the growth of world population over long stretches of time. The population earlier grew very slowly or remained stationary and began to increase rapidly only during the last half century.

A few attempts have been made to arrive at the population of the Indian sub-continent for various historical periods on the basis of fragmentary recorded army statistics, land revenue records, the nature of contemporary economy and diaries of foreign travellers visiting India. According to Pran Nath, the Indian sub-continent's population around 300 B.C. was between 100 and 140 million, the only estimate available for this period. This is apparently a very high figure, for the

total world population in A.D. 1 is estimated to be around 250 million. If, however, this figure is accepted, the population apparently remained more or less stationary for almost 2000 years, upto 1600 A.D., incredible as it may sound, as a result of high death rates cancelling high birth rates. If one may speculate in the absence of any appropriate reliable data, India's population in ancient times might have fluctuated much as the world's population did–a very slow increase over long stretches of time and periodical loss of even the little natural increase through widespread famines and epidemics.

In A.D. 1600, the population of the sub-continent, undivided India, excluding Burma and Sri Lanka, according to rough estimates, was about 100 to 130 million. (The world's population then was probably about 500 million.) During the next two and a half centuries (upto 1850) the numbers, according to several rough estimates, reached about 150 million – a 20 million addition over a period of 250 years–hardly an increase if the estimates are accepted.

High birth rates were probably matched by near-high death rates. Many factors contributed to the latter, among them the wars the European imperialist nations waged against the people of India as well as the wars between Indian rulers for political supremacy. These eighteenth century wars contributed to extreme political instability, economic disorganization, famines and epidemics, resulting in heavy mortality. According to some contemporary accounts, a traveller came across a flourishing town or decimated countryside, as the fortunes of war rose and fell. However, with the establishment of British rule and restoration of a measure of internal peace in the sense of averted wars, and the setting up of skeletal health and medical services, the population began to grow, slowly upto the turn of the twentieth century and rapidly after 1921.

Table I summarises the growth of India's population from the earliest times to 1971.

During the first fifty years of India's century-old census history, 1872 to 1921 (the first census was taken 1871-72), India's population increased by about 60 million. But during the second half of the century (1921–1971) the population increased by 296 million, nearly five times the increase in the first half. The year 1921 proved to be a great divide, when the nation began slowly to control famines and epidemics. The result has been not only a great multiplication, but the multiplication itself has been going on at an accelerating rate.

According to the 1971 census, the nation's population was 547·9 million. This represents an increase of 24·8 per cent or a total of 108·70 million from 439·20 million in 1961 as against an increase of 21·64 per cent between 1951 and 1961. Today the population is about 600 million. At the current rate of 2·5 per cent annual increase, the population may well reach 807 million by 1985 and exceed a billion by the beginning of the next century.

TABLE I

Growth of India's Population, 300 B.C. to 1971 A.D

Period or Census year	*Population in millions adjusted to the present area from 1891*	*Increase or decrease in millions*	*Percentage variation during the preceding decade*
300 B.C.	About 100	–	–
1600 A.D.	130	–	–
1750	·130	–	–
1847	133	–	–

TABLE I (*Continued*)

Period or Census year	*Population in millions adjusted to the present area from 1891*	*Increase or decrease in millions*		*Percentage variation during the preceding decade*	
1871–1872	190·0	–		–	
1881	206·0	16·0		8·37	
1891	236·7	30·7		14·88	
1901	236·3	0·4	61·4	0·20	32·32
1911	252·1	15·8		5·73	
1921	251·4	0·7		0·31	
1931	279·0	27·6		11·01	
1941	316·7	37·7		14·22	
1951	361·1	44·4	295·5	13·31	117.54
1961	439·2	78·1		21·50	
1971	547·9	108·7		24·80	
1981 (estimate)	668·2				
1985 (estimate)	807·0				
1991-2000 ,,	950-1000 ?				

It is impossible in a brief essay to go into varied details, much less a sophisticated statistical analysis. Only a few broad categories of population composition based on the 1971 census results, which have some bearing upon the problematic nature of the population crisis, are touched on here.

India, with a population of about 600 million today, is the second most populous country in the world. The People's Republic of China comes first with about 850-900 million population. It must be added that this is a guess estimate for even the rulers of Communist China either do not know or at any rate do not reveal the exact population of their country.

India's population as already observed was, according to the 1971 census, 548 million. The largest of the States, Uttar Pradesh, has a population of over 88 million, while several states like Jammu and Kashmir, Himachal Pradesh, Tripura, Manipur, Meghalaya and Nagaland have populations below 5 million. Among larger States, we have Bihar (56 milion), Maharashtra (50), West Bengal (44), Andhra Pradesh (44), Madhya Pradesh (42) and Tamil Nadu (41). Among the Union Territories, Delhi had a population of a little over 4 million, but the population of other Union Territories was below 1 million each.

India has one of the highest densities in the world. The over-all density for the country as a whole is about 178 persons per square kilometre. There are wide differences between regions (which show that Kerala is overcrowded and needs relief) to 31 persons per square kilometre in Nagaland. While 20 per cent of the population is classified as urban, it should not be taken to mean that as in advanced countries, the urbanites have most of the necessities or amenities of life. The degree of urbanization ranges from 31 per cent in Maharashtra to 7 per cent in Himachal Pradesh.

According to the 1971 census the wide inter–state differences in density among the various states are as follows: The highest density among the states was in Kerala (549), followed by West Bengal (504), Bihar (324), Tamil Nadu (317) and Uttar Pradesh (300). At the other end of the scale, the density was below 100 persons per square kilometre as in Madhya Pradesh (94), Rajasthan (75), Himachal Pradesh (62), Manipur (48), Meghalaya (45) and Nagaland (31). Among the Union Territories the density for Delhi was as high as 2,738 persons per square kilometre on account of its metropolitan character.

As for the age composition, India's population, like that of many developing countries, is relatively young with a broad base. Forty-two per cent of the people are below 15 years of age, 52 per cent in the age group 15-59, while those above 60 are only 6 per cent. The fact that more than 58 per cent of the population are below 25 years of age indicates a large potential for future growth of the population. The economic development of a country depends to a large extent on the quality and quantity of the labour force available to carry out various developmental projects. India's disproportionately large juvenile population has two disadvantages. One is the large dependency ratio. The working labour force is small and has to support a large dependent non-earning youthful population. Secondly, a large proportion of children in the population prevents women from entering the labour force. This promotes fertility in the long run, for a deterrent to fertility is women's increasing participation in the nation's labour force.

The relationship between female labour force participation and fertility is generally negative. Apparently two factors enter the picture. One is the proclivity of infecund women to enter the labour force and the other is the general control of fertility by women who prefer employment outside the home to the role of homemaker and mother.

As for sex composition, India has had a culturally and genetically conditioned adverse sex ratio for a hundred years. In the 1971 census there were 930 females per 1000 males. Only one state, Kerala, differs in this regard, with 1015 females per 1000 males.

Two other traditional features mark India's social scene. They are early marriages and the universality of marriage. For the population as a whole, in 1971 about 50 per cent of

the population was unmarried, 43·5 per cent was married and about 6 per cent widowed. Those divorced and separated formed only 0·3 per cent.

According to the 1971 census, only 33·8 per cent of the population, excluding children below 5 years of age, were literate for the nation as a whole. As for sex components of the literacy rate, 45·3 per cent were males and 21·5 per cent females.

The religious composition of India's population is of more than casual or nominal interest. Unlike in most advanced countries where the average citizen has developed a secular outlook, people in India, as in most developing countries, attach considerable importance – sometimes fierce loyalty – to a citizen's religious affiliation, even when such affiliation is usually nothing more than an accident of birth.

In 1951 the Muslims were 9·9 per cent of the total population. Their proportion increased slightly to 10·7 in 1961 and 11·2 in 1971. As for the Christians, the percentage increased from 2·3 to 2·4 and 2·6. The Sikhs registered a similar small increase from 1·7 to 1·8 and 1·9 per cent.

The cultural, communal, ethnic and linguistic diversity of India's population can be seen in the hundreds of caste and tribal groups, almost a score of major languages and hundreds of dialects. The weaker sections of the country's population – the Scheduled Castes and the Scheduled Tribes – account for nearly 22 per cent of the population (14·6 and 7 per cent).

Looked at another way of the world's total population, every seventh person is a citizen of India. And every seventh Indian is a Harijan (ex-untouchable) or member of the Schedule Caste, more than 85 million in absolute numbers.

What Exactly is India's Population Problem? Perennial Poverty?

In demographic terms, India's population problem can be summarised into a basic and simple question. It is: how can we raise our standard of living and level of consumption (which means roughly more of everything for everybody) and cut down our relatively high death rate (which means keeping alive more people and for longer periods who would otherwise die prematurely) when we are unable to support the existing population at a very low level of living, if at the same time our population continues to increase by thirteen million every year? That is, in a sentence, we are demographically running so fast that economically we are forced to stand still. In other words, our population problem is simply a question of our perpetual poverty.

What is poverty? What do we mean when we say that India is a poverty-stricken country? What is the magnitude and dimension of our poverty? Our nation has often been cited as a country of "stark", "naked", "shameful" and "incredible" poverty. The dictionary defines the word as "lack of money or material possessions and an extreme want of necessities". No matter what the adjective used, the simple fact is that a majority of our population–particularly in rural areas and urban slums–is denied the irreducible minimum requisites of decent human existence in terms of simple but nutritious food, clean clothing, minimum housing, effective literacy, if not purposeful education, and exposure to certain activities of a cultured life.

What are the causes of our national poverty? This question deserves a serious, albeit brief, examination.

First, some, mostly foreign students of our mores, contend that our people are poor because riches do not attract us. That

is, we believe in simple living and high thinking. Simplicity to the extent of austerity and even denial is supposed to be our spiritual way of life because the world is all *maya*, a passing illusion (if not hallucination), a turnpike through which we must perforce pass to reach our reserved seats in a non-geographical, post-mortem heaven.

One need hardly reply to this contention beyond saying that it is simply not true. Whatever might have been our past beliefs and practices, *today* even our maharishis, yogis and so-called godmen want air travel, air-conditioned rooms and transistor radios. Certainly the common man in India today wants decent food for his family, adequate clothing and shelter, education and medical care—and we must rejoice that he has now awakened to wanting them, even if he had not done so in the past.

The second school explains our poverty as a result of imperialist or colonial exploitation—the British rule of India for nearly two hundred years.

We have been saying this for nearly a century and the contention is at least as old as the Indian National Congress. Obviously the British or any other imperialist rulers did not conquer and rule any colony primarily in order to promote that colony's interest. The British siphoned off India's raw materials to feed Britain's hungry machines and dumped British manufactured commodities on the Indian market with the aid of preferential tariffs to keep the British economy going. But while all this is undoubtedly true, an objective balance sheet of British rule in India, with the assets or worth-while institutions established versus the liabilities of the depth of their exploitation clearly defined had yet to be drawn up.

It is interesting to note that the obverse of the argument does not really follow. By this we mean that nobody expected

that the day the British ceased to rule India, the country would become rich. And while the country's prospects have considerably improved since the advent of freedom, our national income statistically does not show that the lot of the common man has improved substantially in the last three decades.

It is noteworthy that certain countries—Thailand, for example, and certain Latin American Republics which were never very much or for very long under foreign Spanish or Portuguese colonial rule, remain poor today, or at least not particularly well off.

A third school maintains that India is poor because of poverty of natural resources. The argument here is that were India blessed with enormous quantities of iron, gold or oil resources she naturally would be rich. A country's natural resources are a matter of geological accident. Nepal or the Mongolian People's Republic, without any great resources, or a nation carved out of the Sahara or the Atacaman Desert is not likely to be or become rich, but little Kuwait or any Arabian Sheikdom with oil can have a high per capita income.

Actually, India is neither rich nor poor in the matter of mineral resources compared to various other Asian or African countries. But what matters is not how much we have but what we are able to do with what we have. It is possible that a thorough modern geological combing survey of our country might reveal latent resources that are commercially exploitable, as indeed has been the case with oil recently. What is needed is a coherent national policy of evaluating the magnitude of our resources and then unearthing them with the latest technological know-how in a meaningful, carefully coordinated plan of national development.

It must be pointed out, however, that a country like Switzerland, with no great resources, can be an affluent country. The Swiss, through their imaginative hard work, have converted their rugged mountains ordinary plains and lakes into beautiful places to attract tourists, and consequently, income. India with her vast resources of historical, architectural and sculptural treasures of great beauty, could attract countless tourists from all over the world if we could transform through hard work our squalid and unsanitary environment to one of clean, healthy beauty.

The fourth school contends that capitalist exploitation is the cause of our poverty. Not foreign imperialist exploitation but native capitalist exploitation of the industrial workers–the problem of a very small minority of rich industrialists exploiting the poor workers. Millions of words before and since Karl Marx have been written on this subject and there is no need to dilate upon it.

The argument is fairly simple. Why should an industrial worker sweat eight hours a day if he cannot get a living wage and a minimum level of comfort if a disproportionately large share of the profits is enjoyed by the capitalist or industrialist ? Or why should a landless peasant toil from dawn to dusk and till the meagre land with a primitive plough if a lion's share of the produce is enjoyed by an absentee landlord ?

These are natural and legitimate grievances and modern society has accepted them as justified. Agrarian reforms and modern labour laws are trying to ensure that more equitable returns are guaranteed to those who work, through reform of land tenure, minimum wage laws and better living conditions for the worker. The cause of the common man is accepted all over the world today and not only in communist countries.

According to the fifth school of thought, our poverty is due to lack of economic development and not due to excessive population growth. The controversy over the relative merits of "economic development" versus "population control" is a familiar one. It is unreasonable for any demographer or politician to waste time, when time is of crucial importance, arguing whether the *central problem* before India and the developing Third World is population control *or* economic development. One school, the so-called neo-Malthusian school, contends that a country cannot register any marked economic growth unless the rate of population growth is curbed. In developing economies, the hard won slow growth in national income tends to be eaten up by the large increase in the population, leaving per capita income and consumption levels almost as low as before.

But the Marxist school contends "while under the capitalist system, growth of production means growth of the wealth of the exploiting minority, accompanied by the impoverishment of the working masses, both relative and absolute, under socialism production is developed for the benefit of society as a whole, namely in the interest of meeting the expanding material and cultural requirements of all the members of society and increased production means a steady improvement of living conditions".

This debate looks as rational and fruitful as the controversy whether the chicken or the egg came first. What is really needed is *both* population control and a saner (or more just) system of economic distribution to ensure rapid economic growth. The controversy would be relevant only if demographers ever aver that family planning alone would deliver economic development, and, to my knowledge, no demographer worth the name ever has. In a word, *both*

these approaches should be viewed not as ends in themselves but as a means toward the higher goal of achieving a better quality of life and human fulfilment.

The sixth and final school of thought contends that our poverty is due to over-population : too many people for the nation's available resources including land, in the context of our low level of technology. Table No. 1 which summarises elsewhere the growth of our population shows that since the nation became independent in 1947, 267 million people have been added in about thirty years. There is no need to repeat certain striking demographic facts noted elsewhere in this paper, and it is obvious that by adding the numbers we do every year, we are making our problem more and more intractable. One simple way to look at this is to imagine how much easier life would be for everyone if we had say a hundred or two hundred million less people in the country today !

There is the old saw that every mouth brings with it a pair of hands. But, unfortunately, the pair of hands takes about fifteen to twenty years to grow up, learn a skill and earn a living, while the mouth begins to function automatically.

Another answer might be that certain sparsely populated countries like Afghanistan or the Mongolian People's Republic, in terms of density of people per square mile or number of people per cultivated acre or whatever the criterion, remain relatively poor, while densely settled countries like Japan, Belgium, or the Netherlands are affluent. If over-population leads to poverty it is often equally true that poverty breeds over-population.

However, it must be pointed out that India's present per capita income of about Rs. 750-800 is among the world's lowest. Since planned economic development began in 1951-

52 the Indian economy has registered an annual growth rate of 3·2 per cent, while during the first fifty years of this century the Indian growth rate was less than one per cent. Viewed against the population growth rate of 2·1 per cent during the Plan period, the per capita income has risen at an annual rate of barely 1·1 per cent.

Certain developing countries in Asia, Africa and Latin America have achieved higher growth rates during the same or comparable periods. India's total national income increased of course, but thanks to the massive additions to the population, the *per capita* income registered a poor rate of increase. The gains registered in India's national income were absorbed by the growing population to maintain the existing low level of living, leaving only a small margin for capital formation and investment instead of increasing the *per capita* consumption of badly needed goods and services. A large part of India's national income is utilized for demographic "investment" (part of it is demographic wastage because of our high infant mortality rate) which is nothing but an unrewarding expenditure to maintain a growing population at a constant low standard of living.

There is no need to offer any more evidence–much is available in official publications–to show that despite considerable economic progress registered during the last two and a half decades of planning, for millions of rural and urban citizens economic betterment has been minimal or even non-existent because of our rapid population growth.

While it is true that causes of our poverty are many and complex, it is obvious that a lion's share of our difficulties must be placed at the threshold of our national population explosion.

Julian Huxley has summarised in his John Danz Lectures the world's demographic explosion and its threat to the quality of human life in even advanced countries :

> "To sum up, the world's demographic situation is becoming impossible. Man, in the person of the present generation of human beings, is laying a burden on his own future. He is condemning his children's children to increased misery ; he is making it harder to improve the general lot of mankind ; he is making it more difficult to build a united world free of frustration and greed. More and more human beings will be competing for less, or at any rate each will have to be content with a lesser cut of the world's cake. If nothing is done about this problem by us who are now alive, the whole of mankind's future will suffer, including the future of our own children and grand children. The next twenty-five years will be decisive."

One does not have to wait a quarter century to visualise this grim picture for it is already largely true of India and many developing countries today.

Population Policy Perspectives

What is a population policy ?

The size and composition of a nation's population may be altered by many factors, some of which are without any deliberate human intention or intervention. The failure of a monsoon, the discovery of a drug, the invention of a machine, the devastation of an earthquake or the advent of war may exercise considerable influence upon births, deaths, morbidity, marriage and migration within a country.

However, a population policy is made up of Government measures and programmes, legislation and directives designed to achieve certain economic, social, cultural, or political goals

with the overall objective of changing the size, composition, and the geographic distribution of a nation's population. In the larger sense, a population policy is an integral part of a development policy and program.

And population policies are of various kinds, pro-natalist, anti-natalist, pro-status quo, etc. In all their subtle variations the policies are of as many kinds as there are governments from the People's Republic of China and the Soviet Union to the governments of Spain and Portugal. But the population policies of most countries in the past have been pro-natalist, involving cash bonuses to families with a large number of children or modifying the tax structure in favour or large families, and making available certain social services like maternity benefits, free medical aid and cheap housing to lessen the burden of large families.

A population policy for India must aim at the rapid and simultaneous reduction of birth and death rates. While everyone knows that our birth rate is high (we are adding 13 millions or an Australia or a Sri Lanka or a Taiwan every year to our population) it is not generally realised that our death rate is also high in relation to the advanced and even certain developing countries. The nation's infant mortality rate is still around 100 per 1000 live births, while in all the advanced countries it is less than 20.

We know today that any country can *buy* the death rate it wants. Both the scientific knowledge in pediatrics and the simple technological know-how of infant care and its delivery to mothers in homes are available. But the country's priorities must change ; and if the country is willing to spend on public health and sanitation, water supply and nutrition and overall preventive and social medicine sufficiently large sums, the general death rate and its components of both infant and maternal mortality rates can be brought down dramatically.

We are unfortunately so tragically and thoughtlessly conventional that reduction of the death rate simply means more clinics and hospitals, more medical and para-medical personnel and more drugs and dressings. But diagnostic and curative services, while needed, are wasteful in the long run. What is far more desperately needed is Preventive and Social Medicine. The community's and Government's motto ought to be "prevention is better than cure." It is now established that roughly a third of our death rate is accounted for directly or indirectly by bad water supply, another third by our incredibly poor sanitation and public hygiene, and the last third by poor nutrition. Would it not be better to improve these conditions and reduce the death rate than to go on merely increasing the existing diagnostic and curative services?

It is my thesis that a drastic fall in the infant mortality rate will result *pari passu* in the decline in the birth rate. Today most couples have about 6 or 7 children in the hope that at least 2 or 3 will survive to adulthood, and at least one or two, if they happen to be sons, will take care of the parents in their old age, in the absence of any national social security system or old age benefits. Once the parents realise that most, if not all, of the children they have will survive to adulthood, then they will not have more than 2 or 3 children. This has been the historical experience of many cultures and nations and there is no reason why India should not conform to this process.

Fortunately, in our country there is one major silver lining in the growing dark cloud of population growth, natural resource depletion, environmental destruction, pollution of air and water, urban blight and overcrowding, and dehumanising squalor. Whether the average citizen is aware or not of the threat of uncontrolled fertility to his present plight and future prospects, the nation's Government is so

progressive that it realises that excessive population growth is at the centre of the problem of poverty in our country today. There is a welcome determination to solve the problem of India's population growth. And hence the new National Population Policy of the Government enunciated by the Union Minister for Health and Family Planning in April 1976. The citizen has no need to fight any battles for such a progressive policy, as was the case in most of the Western countries. All that is necessary is for him to take advantage of the Government's measures, thus promoting his own welfare as well as that of the country. The need to intensify family planning work all over the country cannot be overemphasised.

Conclusion

To sum up, the fundamental biological obligations of all married couples in the future should include :

1. Limiting their family size to two children, spacing the arrival of these children and not under any circumstances producing unwanted children. (The third child must be considered an unwanted child by society.)
2. Not producing children in response to political demands, religious injunctions, or cultural compulsions.
3. Not producing children whose physical and mental endowment would be defective or less than normal (assuming the knowledge of such a possibility is available to parents.)
4. No couple should assume that the small family norm is applicable only to the poor and the underprivileged and they are exempt by virtue of intellectual

superiority, wealth, or physical stamina. Those couples determined to have more than two children should adopt homeless children who are already in this world.

It is true that time is running out, but there is no need for pessimism. The time we waste on bewailing our plight and denigrating our achievements can be better spent on constructive thought and action. We as a nation need more discipline and dedication. We also need perseverance and sustained effort. With these we are bound to succeed.

Science and Peace

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Even as these lines are being written, the newspapers report (6th September, 1976) a world meet at Manila on the survival of mankind menaced, it appears, by a multitude of problems from ecology to economics. Last month many people in different countries remembered Hiroshima and Nagasaki which had witnessed, thirtyone years ago, the gruesome lunacy of war. The United States' atomic assault on already nearly defeated Japan was, like an attack against locusts or fungi, bereft of human qualms—not a permissible, if heightened, phase of combat but a cruel and senseless essay in extermination. There has yet been no full count of the victims of that nuclear abomination, because the death toll is still rising, even the children of those within the lethal radius in August 1945, are being carried off by radiation disease, and for years after the event large numbers of men and women, not daring to go out in the streets for fear of the repulsion their disfigurement might provoke in passers-by, have been dying of leukaemia. Hiroshima and Nagasaki were a terrible portent, for the atomic weapon was not just another bomb but a new and final step in warfare, the destruction of man by man. Even so, there has been since then not only the mounting accumulation of nuclear weapons but also the emergence of other monstrous means, chemical and bacte-

riological for instance, of mass destruction. No wonder that in the perspective of history, mankind stands today at a point which marks either the beginning of the end of war or the beginning of the end of humanity.

The atomic and hydrogen bombs could be possible because of a tremendous fundamental discovery in pure science, that of the theory of relativity by the great Einstein, one of the most truly compassionate of men, in 1905. Other scientists, some of them superb in their sphere of knowledge and also noble individuals, had carried on work on the theory. With no motivation other than the advance of pure science and without the slightest idea or intention of its use for military purposes, a brilliant band of scholars made in 1938 the epochal discovery of nuclear fission. It was, however, a stupefying shock to humanity when in August, 1945 Hiroshima and Nagasaki were victims of the most diabolic mass murder in history. Even the few top scientists in the United States (and also outside) who were in the know of the death-dealing mechanism had hopes that it would never be used and were also personally very much against its use-though, as Dr. D. S. Kothari once said, none of them found it possible to register a public protest at the time. It will not be surprising if, recalling Hiroshima, one is driven to contemplation, at the same time, of the madness of war and the culpability of science.

It is not science, however, which is culpable but the ruling elements in exploitative society who force science to subserve their often monstrous interests. Bertrand Russell once said, with the bitterest irony, that if any folly or crime, however cruel or despicable, was at all possible, then man would commit it. That, however, is not and cannot be the whole story. One thinks of the episode, a few months before the Hiroshima malignity, of Winston Churchill's meeting

with the then acknowledged leader of atomic science, Niels Bohr, when the latter found himself unable to tell the British Prime Minister what was gnawing in the scientist's mind about the implications of the bomb—when Bohr asked if he might send Churchill a memorandum he was repelled with the reply that while any communication from the great scientist was an honour it should not be about politics! The establishment of truth, which is the passion of science, is not by itself enough to channel its effects into the right direction. This is why the communication gap between science and politics has to be bridged. This is why one should be drawn towards the thinking of Karl Marx who advocated, perhaps for the first time, or in any case most consistently, the real subordination of developing technology to genuine human needs. This is why socialism which recognises the absolute necessity of technological progress seeks to add humanist sense and significance to that progress, and while reliant largely on science for the re-making of man insists that the long-range goals of humanisation of the scientific and technological revolution are understood and assimilated by engineers, economists, technicians and community organizers thinking and working together. In the conditions of today it is imperative that men of science as well as all people of good will meditate on the purpose of science, its role in history (on which J. D. Bernal, powerful crusader for a "World Without War" made a most notable contribution) and the ways and means of ensuring for all mankind what Dr. Kothari called in his Zakir Husain lecture "the *human* use of human knowledge" by vanquishing the powerful vested interests that block its path. Science means knowledge, and as the old and wise Greek saying has it, "Knowledge is power"—power without which social engineering cannot take place. Whether it is done for good or for evil depends on the wisdom and understanding that informs society. The

same science which made the atom bomb can be the strongest instrument for realizing enormous possibilities of happiness and security for all mankind.

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A campaign is now under way in all countries for the collection of signatures to the World Peace Council's new Stockholm Appeal for a stop to the arms race. From the Soviet Union, whose first great slogan (November, 1917) was "All Power to the Soviets, Land to the Peasants, Bread to the Starving. and Peace to All Men", and whose record since then in the sphere of disarmament effort has been consistent and constant, the report comes that by 15th August, 1976, the number of Soviet signatories to the Appeal was 159,940,000. The success of this campaign, plain for all to see from reports coming in from many lands, derives from an awareness of the salient international fact of life today—the fact that mankind is tired of living on mountains of weaponry and realizes the folly of the situation and the fundamental frustration, which it connotes, of all idea of the well-being and advance of humanity.

Science is no fairy godmother that will shower gifts in miraculous fashion on people who have not worked hard to get them. We in India have a long way to go, for in spite of being today the country with the third largest number of 'scientists' in the world, we are, for a multitude of reasons that cannot be explained here, still very much underdeveloped. The United States of America, with the world's biggest resources in scientific and technological equipment and talent, sustains also a system of military pacts, aggressive bases in many lands, centres of corruption and bribery, subversive propaganda and espionage, overt or covert action,

terror and threats (cf. C.I.A., Lockheed *et al*) which imperialism, howsoever shrouded, cannot abandon on account of its rapacious and exploitative nature. For such purposes alone the U.S. today invests more than 120 billion dollars a year, a figure which, Cuba's Castro said recently, was "twice the combined budgets of the Latin American countries". Vietnam, with the U.S. requisitioning even chemical and bacteriological weapons to compound the infamy, is a noxious memory that cannot be easily effaced. And yet it is science which tells us that what might be termed 'Operation Plenty' for the entire globe, including advanced as well as backward countries which in fact need each other in the quest for a better life, is far more likely of success than any military operation in any war, though of course, like military operation, it needs to be thought out, planned and executed, not only with intelligence but with general goodwill, energy and enthusiasm.

Perhaps our scientists, by and large, are still somewhat remotely placed from the main centres of the lethal activity to which a great deal of scientific talent is made to turn, but they know very well the central role today of military technology in the financial support of 20th century scientific research. They cannot be unaware that the arms race is going on–the United States' military budget having already topped 100,000 million dollars and likely to run up to 113,000 million next year, the Federal Republic of Germany allocating 47,600 million marks, France 50,000 million francs, even Britain having a military budget of 5,632 million pounds, China also stepping up the arms race by spending 40 per cent of her budget for military items. This basically non-productive expenditure, accentuating inflation and turning economies lopsided, is sought by 'Western' governments to be explained by the "danger" from the Soviet Union. Undoubtedly,

the Soviet Union takes note of the realities of the world about it and makes sure, as far as it can, of its security : the motto seems to be to trust in the ways of peace and "to keep its powder dry". It is a fact, however, that over the years 1970–73 the Soviet Union's military expenditure was maintained at 17,900 million roubles but since 1974 has been kept at the reduced level of 17,400 million roubles—a figure which placed alongside the U.S.'s, will speak for itself. Besides, the Soviet Union unceasingly pursues the ways of peace–detente, nuclear disarmament, total banning of chemical and bacteriological weapons, about all of which NATO powers are indifferent. Allegations about the Soviet "threat" are no more than a cover to speed up the arms race, oppose the relaxation of tension and keep the world, as it were, on tenter-hooks so that the military–industrial complex in the affluent countries can make the globe safe for themselves.

Regarding the so-called "hawks" who demand continuous development and stockpiling of nuclear weapons, Adlai Stevenson, once the Democratic Party nominee for U.S. Presidentship, said in 1960 that if U.S. scientists continued their work in this field, scientific progress could, by 1980 and maybe even earlier, produce a way of effecting an absolute explosion, with one push of a button, which would be enough to lay the earth waste. That would, of course, be super-suicide, but perhaps certain interests in the world like to echo an old American saying : "Better dead than red". The common people anywhere, however, never have such frenzies, but 'Western' governments : unwilling to stop the arms race and the trade in death-dealing weapons – *pace* the present-day boom over arms supplies to Arab countries and Iran and Pakistan apart from the perennial American bonanza which sustains a tiny state like Israel—appear to

have for their motto : "Better not exist than co-exist"! The silver lining, however, is seen in the fact that the forces in favour of relaxation of tension and of peace are growing into such strength everywhere that the "hawks" cannot have their way.

* * * *

There is practically no limit to the growth of armament costs of conditions of the scientific and technological revolution. New types, new systems of weapons of mass destruction, more devastating than previously, also cost more. Not so long ago, every American Polaris-type submarine cost 244 million dollars; one Trident–type submarine equipped with 24 intercontinental ballistic missiles with a 12000 Km range will cost 1,500 million dollars. The costs of training people to control modern military hardware are climbing steeply at the same time. It will suffice to recall that even back in the 1960's it cost 600,000 dollars to train *every* pilot of an American B–47 jet bomber.

During the early 1960's it was estimated that if the arms race did not stop, not less than three *million million* dollars would be spent for military purposes in the next twentyfive years. This amount of money approximately equals the total value of wealth created from the beginning of history by human labour all over the world. Such figures make the mind boggle and the head reel, but they are there. Between 1949 and 1974 the North Atlantic Treaty Organisation (NATO) spent 1,820 thousand million dollars, that is, 73 thousand million dollars on an average every year. In 1974, the bloc spent almost 135 thousand million dollars—seven times the 1949 figure—and 149 thousand million dollars in 1975. How much will be spent in 1976 is yet undisclosed.

The annual world expenditure on arms today is about 300,000 million dollars-roughly the total income of the poorest half of mankind. When it is remembered that in one year "aid" to what is sometimes called the Third World is about 12,000 million dollars, it will be seen that the affluent powers spend from twenty to twentyfive times more on armament than on help to developing countries. It is no surprise that in the conditions prevailing, the appeal made in 1957 by the eminent scientist P.M.S. Blackett, when presiding over the British Association, for a contribution of one per cent of the national income of the rich countries to help the underdeveloped ones, has remained yet unanswered. The Soviet Union's recent proposal for a 10 per cent reduction in the military expenditure in the military budgets of the Permanent Members of the Security Council and assignment of the savings to assist developing countries remains pending. One cannot spend on "guns and butter", however, at the same time, and so in the 'Super-rich' U.S., the El Dorado of capitalism, the present unemployment figure is 9.7 million that is, some one-tenth of its total manpower. This does not appear to have affected the attitudes flaunted in the current contest for the U.S. Presidency, the candidates vying to have a hoot at Helsinki ('detente') and hallelujah arms accumulation.

Let it be stressed that nuclear war, if it occurs, is a calamity that hardly any will remain alive even to mourn. The Kissingers of creation do not desist from talk of "limited nuclear warfare", dishonest fluke of an idea which in any case is also fraught with immeasurable evil to man's life on this planet. Bernal once wrote that after a nuclear holocaust, maimed and crazed remnants of humanity might creep back to some form of life, that too perhaps only in the least affected areas like Tristan de Cunha or Terra del Fuego–such

remnants being the least likely to retain the possibility of civilisation. With a peculiar perversity Mao-ist China appears to have conceived of large chunks of humanity avoiding atomic damage and spectacularly builds underground shelters against nuclear attack. A 1957 estimate mentioned 63 billion dollars as the cost of sheltering 87 million U.S. city dwellers underground—a sum, likely to be exceeded many times over, which only the richest countries could conceivably afford. Besides, the utterest maximum for a sizable population to have their necessities stored underground was two years, at the end of which the survivors emerging, if they could into the open, would be not only physically but also biologically devastated. One should not refer to this notion of 'Shelters' in order to make fun of them, but to all practical purposes they are impossible proposition. Those who seriously advocate them perhaps have motivations which are better not analysed. The real task is to stress and make sure that humanity must exorcise the gruesome spectre of nuclear war and make our planet safe for man and the environment of nature in which he has learnt to rejoice.

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At the same time as man contemplates today, for the first time in history, the possibility of the horrible destruction of civilization and of life itself on earth, he knows, thanks again to science, that life can be made happy and worth while for every one in the human family by applying human knowledge for human well-being. In hundreds of ways, as can be noted in daily life, labour can be eased and healthy enjoyments increased. By wise economic policy and the full use of science the disparities that plague our life in many ways can be removed. The contrast between the standard of life in developed countries and others in different stages of under-

development is a phenomenon that cannot be endured much longer. Three-fourths of the world living in semi-starvation, disease and enforced ignorance is something which must be a thing of the bad old past and science can do the job. Who says the world is filling up too fast with people and our problems are insoluble? What, indeed, would life be without problems to solve and hurdles to climb over—these are excitements that are the stuff of existence, excitements unknown to the monotony of ceaseless and dull contentment that is supposed to be characteristic of life in paradise? There is no insuperable difficulty, as any serious scientist would agree, in feeding even a 5 to 7 billion population by 2000 A. D. provided the necessary steps are taken—which is not to imply that the 'population explosion' is no cause for worry but only that there is no need to tear our hair and shout lamentations about it. Science knows its limits but is on that very account aware of the enormous area of freedom where it can work and produce results. The pride as well as the humility of science is seen so radiantly in Archimedes' affirmation that if only he could gain a foothold outside, he could lift the earth with a lever. If only our scientists get their sights right, they can make sure of the upliftment of our race and our environment. Let the economic and political priorities involved in the practical and truly beneficent application of scientific research be determined and the work of our scientists, in pure theory as well as practical results, will help the task of social reconstruction so long yearned for.

Great and complex problems are there for science to tackle–the origin of life or the control of weather, for example. which cannot be tackled inside the scope of a single mind however well trained, and co-operative scientific research is essential, but it is still often clumsy. How heartening is the

international co-operation, for instance, in space research, the successful prosecution, in spite of the Soviet Union and the United States being qualitatively different entities, of the Apollo - Soyuz programme, also such things as the Indo-Soviet collaboration in the launching of Aryabhata ! How putrid and perverse is the prosecution of programmes of annihilation, the stupid and diabolic arms race that threatens to put out the lamps of beauty that civilization has lit, after centuries of labour, on our planet ! How incumbent it is on scientists who know that their knowledge is power and should be channelled in directions that help the onward march of humanity !

It may be that scientists often plead their lack of responsibility for the uses, good or bad, to which their ethically neutral discoveries are put. With all respect, it has to be said that such pleas are pallid and fundamentally insincere. No man is an island ; there is no escape from the earth, even for the scientist imprisoning himself so to speak in his laboratory, no escape from the human microcosmos. For the scientist today there is no excuse for not knowing that he belongs to society, that he can believe in no escape to a transcendental heaven, that he has all the time he works a responsibility to himself and to the future of mankind.

Many years ago Jawaharlal Nehru had proclaimed his faith that "Science alone can solve the problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by starving people." "The future", he said, "belongs to science and to those who make friends with science". That future requires to be assured by the worldwide struggle for peace and against the forces that make for war. No wonder that Joliot–Curie and Bernal felt so passionately on the point and plunged deeply into the

movement for peace. No wonder that Meghnad Saha and D. D. Kosambi and Homi Bhabha avidly joined that movement. Let Indian scientists come forward in this task which is in consonance with all that is vital in the traditions of our ancient country as well as of all humanity.

Science and Pollution of Our Spiritual Lives

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In my visits abroad, I have often been asked why only in India there is a large percentage of intellectuals who believe in the power of the "spirit" to contradict the laws of science even to the extent of shaking its very foundations. Many Indians, I take it, are proud of the fact that we are a "spiritual" country and are happy when the "so-called intellectuals" support the superiority of the power of the spirit against the established laws of the rational sciences. Before we discuss the reasons for such behaviour, it is perhaps best to define what is meant by a "so-called" intellectual, spirit and the foundations of science.

In India, an intellectual has many connotations. He could be defined as one who has a kind of education in the pre-independence British style mostly inspired by Lord Macaulay, which means he is able to read and write (particularly with a background of Western literature) and accept without using much of his critical faculty all that he reads. An intellectual could also be one trained in the old style based on Sanskrit or Islamic culture, and for fear of losing any part of that great but confused legacy is again

willing to suspend all his critical faculties in an envelop of conservatism. The most controversial of those included among intellectuals is the man educated with a science background specifically trained to question the validity of assumptions in the presence of observed verifiable data, but is willing to suspend all his training and even principles to become part of a society which encourages one to accept "spiritual solace" through a Guru at the first sign of personal trouble or gain even if it can lead to obvious inconsistencies like $1 = 2$. There are of course many scientists who are genuinely moved by spiritual impulses and do not mix affairs of the spiritual world with that of the material and we take note of the fact that whatever the origin of the spirit it is this that motivates change and evolution as we know it.

Nobody can deny that speaking from a purely physical point of view, a system of biological cells on integration forms itself into a living object whose behaviour can at the present not be described in purely physical terms. Whether the integration produces consciousness leading to acts spiritual, or whether consciousness as a separate entity resides only in such integrated systems is yet an open question. But whichever way you take it, as far as we know, there are no scientific inconsistencies generated by the activities of the material world motivated by our inherent consciousness. The laws of energy conservation and entropy seem to be obeyed from all experiments with biological matter in the laboratories. While the spirit is sustained by matter, there is nothing to suggest that the spirit in the process of dealing with matter breaks anything of the laws of the material world. It can be used to channelise our energies to get maximum benefit from the material world around us. The main problem now seems to be that we are as yet unable to explain why nature has proceeded along the path it has,

in fact, taken. Many eminent scientists feel that the whole development of the living species is one of pure accident–an act of probability.

Science has, of course its limitations and this is best summarised by A. N. Whitehead who writes :

> " Science can find no individual enjoyment in nature : Science can find no aim in nature : Science can find no creativity in nature : it finds mere rule of succession ".

It is due to the limitations of science we have to attribute much of our creative activity to the spirit or our consciousness with us. Having chosen this path of evolution and knowing that there is established consciousness, it is clear that there is need for ethics and a code of behaviour for collective living. This, I believe, is the primary need for any organised religion. The Buddha discovered all this in clear terms a long time ago.

We now examine what indeed are the "foundations of Science" and what is permanent about it. Even the slightest exercise of common sense will show that we cannot violate the fundamental postulate of Mathematics, that when a theory indicates that two different numbers are equal, it is an inconsistency and the theory must be false. If we have a base which allows for $1=2$, all Arithmetic, business operations, etc., will come to a standstill. It is a fact established out of human experience and all knowledge gathered upto now substantiate this statement. We will now show that miracles and materialisation of macroscopic objects from nothing in the physical world directly contradicts this basic postulate. For this purpose, of all the laws of Physics, I will invoke only one and that is the law of conservation of energy. This great cornerstone of science has been verified by all experi-

ments done hitherto since the beginning of science as we know it. In the early days this used to be called conservation of mass, but ever since Einstein demonstrated that mass and energy are equivalent, the conservation of mass principle has been absorbed by the more comprehensive one. It merely states, you cannot produce mass or energy from nothing and if you could do this, you can as well make the assumption $1=2$. Even if one is willing to give up all other principles in Physics, it is impossible to renounce this particular one, for without it, no space exploration is possible, no atomic devices and in general no technological development of any sort.

The principle of conservation of energy holds good for both inanimate and living matter. We also know that both types of matter are made up of atoms and molecules. Therefore, it should come as a surprise to any scientist how materialisation is possible by spiritual energy which materially is of value zero to produce objects like bhasmum, watches, etc. It has never been clear to me why bhasmum plays such an important part in Hindu religious activity. I can see its value in mythological stories coming from the puranas, but a chemist can only see it as an oxidised form of material from which energy has been removed. I can better understand the desire for people to get wrist watches free of cost especially when we are in short supply of quality types. It is a typical middle class Hindu craving as is exhibited by the insistence of its inclusion as dowry in marriages. That only such types of articles are possible by spiritual materialisation itself destroys all basis for any rational consideration. The simplest alternative explanation would be that this is a demonstration of a sleight of hand or a well contrived magic performance as ably shown by my friend, Dr. Kovoor, who is also able to demonstrate many of these, but requires

no divine inspiration. It is better to believe in Dr. Kovoor than give up everything in science whose benefits we enjoy every moment of our lives.

There are some people who in the process of rationalising everything brought to their attention, say that just as the theory of relativity introduced many paradoxes into physics by invoking a 4-dimensional space, in the same miracles can find an explanation in some higher dimensional abstract space. We only comment that while relativity strengthens all the basis of science, any introduction of abstract spaces to explain away miracles which includes specific materials destroys its very foundations.

I have more sympathy when the so-called spiritual methods are used in the cure of psychosomatic diseases. Medical science has not sufficiently progressed to understand psychosomatic behaviour especially when there is accumulating evidence that most diseases that people suffer from are due to psychological reasons. Wherever there have been cases in which the disease has been properly diagnosed, the prognosis given by the able doctor has always been satisfied and no amount of spiritual infusions have helped. That is what I gather from scientists who have observed these medical cures. On many occasions, these spiritual cures have not worked and have given only false hopes to people around the patients and thereby created more harm than good to anybody. It is indeed a pity that many people are caught up by unverified statements and will swear to you that they have seen these miracles when it was just physically impossible for them to have been there. If out of some kind of psychological shock the patient has been cured of psychosomatic disease, I will say he has been lucky, but I am not sure that the benefits of such cures really outweigh the damage that they have caused to society. It is in

the collection and verification of such data the venture of the Bangalore University can be of great value to all of us. I specially congratulate them for the courage they have shown in starting such a project. It is but right that a university should take the initiative to protect young people from spiritual pollution and exploitation.

No one denies that people require spiritual assistance in the conduct of their daily lives. No one can deny that many works of art and beauty have come out of spiritual inspiration. I would not even stop a man from breaking coconut before the image of his desire in times of stress. I would suggest that the more non-anthropomorphic the image, the better—I personally prefer the image of Ganesha—though the Vedas make worship more abstract and remote and certainly not for gain or fulfilment of desire. We humans have a unique consciousness capable of asking questions about ourselves, why then must we in a fit of fear allow ourselves to be carried away by sorcerers and other questionable people. There is so much in the Vedas to protect us from fear and so much in the work of the Acharyas for philosophical delight and so much for guidance to human conduct expressed as myth in our Puranas. I always like to quote Ananda Coomaraswamy on the value of myth :

> "Myth embodies the nearest approach to absolute truth that can be stated in words."

Unfortunately we have taken myth as it means in words and not as a higher language. This has been our confusion with respect to ancient learning and the possibility of miracles.

How much of a gift to humanity it would be, if our spiritual leaders refrained from impressing upon gullible people their powers by phoney magic, but concentrated on

expounding the great truths in the Vedas and the work of Acharyas. The same power they have over people can be used to give spiritual guidance to people who ill-treat the weak and the young. The injustices that prevail in all sections of our society is appalling. The cruelty in our slums and even middle class societies is unbelievable. In fact, the idea of Heaven and Hell for most people is to relieve themselves of the frustrations and injustices in the world they live in. Miracles can be done to improve the lot of suffering humanity in our midst by spiritual guidance. Why cannot our spiritual leaders concentrate their activities where they are most wanted? Is the demonstration of phoney magic the only way of acquiring power over people? We are a great nation with great depths of spiritual strength, why must we show to ourselves and the world that we are a primitive people soaked in superstition of the lowest sort as to take miracles and materialisation seriously even remotely.

Science and Philosophy

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Historically speaking, science and philosophy do not have separate beginnings. This is clearly seen in ancient Greece, where the "first philosophers" are also the acknowledged pioneers of science. They are called the early Ionians, for they belong to Ionia—a district on the western coast of Asia Minor, colonised by the Greeks before any definite historical record. The first step to science—which is also the first step to philosophy—is taken by them roughly in the sixth century B. C.

From the limited information that survives about them, one may have the apparent impression of their intellectual achievement having been rather trifling Compared to the sophistication Greek philosophy attains in the course of the next few centuries—and compared particularly to the new horizons of knowledge and power science has opened and is opening today—the actual stock of knowledge of the early Ionians is extremely poor. But this is surely not the way of judging their intellectual achievement. Eminent historians of science have explained why it is really momentous.

Referring to these pioneers of both science and philosophy, Brunet and Mieli say, "They observe the phenomena which present themselves to their eyes, and putting aside all

supernatural or mystical intervention, they endeavour to give strictly natural explanations of them. It is in this sense, and by their rejection of magical intervention, that they make the decisive step towards science and mark the beginning, at least the conscious and systematic beginning, of a positive method applied to the interpretation of the facts of nature."

There are thus two main aspects—positive as well as negative—of their intellectual achievement which make it so important for its historical context. Positively, they are the first in European history to depend on the rational processing of empirical data for the purpose of arriving at "the simple conception of nature just as it is without alien addition"—an expression used by Engels to describe the actual meaning of the materialist outlook on nature, notwithstanding all the vulgar vilifications of the very word materialism. This expression is quoted here to emphasise one point. If it is impossible to doubt the basic fact that the first crucial step to science is also the first crucial step to philosophy, it is essential to remember further that the latter is not to be understood here in its eventual form of indiscriminate adventures of ideas, inclusive of those the main purpose of which is to undermine or disown the conception of nature just as it is. We shall later see the significance of this. For the present, let us note the other feature with which science and philosophy first announce themselves in European history.

Negatively speaking, the first philosopher-scientists find it necessary for their main purpose to tear off the mystical veil on nature, which, among their predecessors, – specially the ancient Egyptians and Babylonians, to whom they are greatly indebted for the technological experience and empirical knowledge in other forms,—remains as the mythological-

supernatural mystification of nature, inclusive of course of man's place in it.

Let us see how Benjamin Farrington, one of the greatest authorities on Greek science, analyses this. The first of the early Ionian philosopher-scientists—and therefore the firs tone in European history—is Thales. For all that we know of him, the proposition to which he owes his great renown is quite simple : "The principle (the first, primitive ground) of all things is water ; all comes from water, and to water all returns." Wherefrom does Thales get the clue to this and what in his way of formulating it makes it historically so important ? Answers Farrington, "The Egyptians and Babylonians had old cosmogonies, part of their religious inheritance, which told how the world had come to be. Since in both countries, in cold fact, the land on which they lived had been won in a desperate struggle with nature by draining the swamps beside their rivers, naturally enough their cosmogonies embodied the idea that there was too much water about and that the beginning of things, in any sense that mattered to men was when some divine being did the equivalent of saying, *Let the dry land appear*. The name of the Babylonian creator was Marduk ... What Thales did was to leave Marduk out. He, too, said that everything was once water. But he thought that earth and everything else had been formed out of water by a natural process, like the silting up of the delta of the Nile ... It is an admirable beginning, the whole point of which is that it gathers together into a coherent picture a number of observed facts *without letting Marduk in*."

Apparently, there is something in ancient Babylonia and Egypt that requires this mythological-supernatural mystification of the accumulated experience of nature—something which the early Ionians do not require. Before passing on to see

what it possibly is, it may be useful to follow the Greek experience a little further.

The beginnings in science and philosophy – admirable though these are – prove on the whole short-lived. The movement initiated by the early Ionians makes rapid progress for about two hundred years after them. Then takes place a seemingly strange phenomenon. Philosophy not only breaks away from science but moreover takes a dangerous turn and becomes hostile to science. This is best illustrated with what happens to ancient Greek medicine, which represents the highest achievement of the scientific temper created by the Ionians. A small book called *Ancient Medicine*, considered very important by modern scholars as a specimen of ancient Greek medical literature, gives us the clear impression of how the ancient physicians are trying their best to resist the invasion of the theory and practice of healing by "emphy postulates" fabricated by the philosopher's brain. But they do not succeed and we find that the philosophy that acquires greatest prestige round about the fourth century B.C. wants completely to undermine medicine and, along with it, the very foundation of natural science. The description of this given by W.H. Jones, an eminent authority on Greek medicine, needs to be quoted at some length :

> "So the two methods, that of Greek philosophy and that of modern science, stand face to face. The struggle between them was, for the time being, short. Medicine, almost the only branch of Greek science scientifically studied, was worsted in the fight, and medical science gradually degenerated from rational treatment to wild speculation and even quackery and superstition. The transcendent genius of Plato, strong in that very power of persuasion the use of which he so much deprecated, won the day. The philosophic fervour which longed with

passionate desire for unchangeable reality, that felt a lofty contempt for the material world with its ever-shifting phenomena, that aspired to rise to a heavenly region where changeless Ideas might be apprehended by pure intelligence purged from every bodily taint, was more than a match for the humble researches of men who wished to relieve human suffering by a patient study of those very phenomena that Plato held of no account. So for centuries philosophy flourished and science languished, in spite of Aristotle, Euclid and Archimedes."

Thus, in short, the norm that made the first philosophers also the pioneers of science is swept away by a new norm that invades philosophy. What the early Ionians strive after is the "conception of nature just as it is" and for this purpose they find it necessary to scrap "alien addition" to it. What Plato stands for is "the lofty contempt for the material world with its ever-shifting phenomena", *i.e.*, to scrap the conception of nature as such. Philosophy turns away from science and militates against it. In the history of Europe, for about two thousand years after Plato there is practically an eclipse of science. But what happens to philosophy itself as a result of its turning away from science? During this period philosophy survives no doubt. But it survives with its original vitality drained out.

With the first foreshadowing of modern experimental science, the situation changes dramatically as it were. It is realised by Bacon and Descartes that what in the meanwhile is produced in the name of philosophy is largely of the nature of sheer intellectual garbage. They see the hope for philosophy only in restoring its bond with science. This new orientation given to philosophy by Bacon and Descartes opens a new horizon of optimism. Bacon sees the convertibility of knowledge into power and hence of man becoming "the benefactor indeed of human race—the propagator of man's

empire over the universe, the champion of liberty, the conqueror and subduer of necessity." Descartes wants to be an architect of "a practical philosophy, by which knowing the forces of fire, water, air and the stars, the heaven and all other bodies that surround us, as distinctly as we know the different trades of our craftsmen, we can employ them in the same way to all uses for which they are appropriate and thus become the masters and possessors of nature."

These are heroic words indeed, inspired essentially by the hope of uniting philosophy with science. But, as we shall see, this heroism—like that of the early Ionians—proves short-lived again. Before coming back to all this, let us try to have some more idea of the events that take place in the ancient period.

We have already seen that the first full horror of the complete wreck of the science-orientation of the philosopher is to be found in the writings of Plato. He has undoubtedly one of the best brains of which human history holds record. It is thus impossible to imagine that any dearth of intellectual capactiy leads his thought to take such a vicious turn against science. Apparently, there is something else altogether—something other than both science and philosophy—that coerces his consciousness to take such a turn. From the standpoint of science at any rate, this something is presumably ugly. What then can this be? Here again we are confronted with very great difficulty. Plato remains almost without a rival in world-philosophy in sheer literary grace. Can it be that the exquisite beauty of his writings wants to conceal anything ugly from our eyes?

Fortunately, Plato himself gives us very definite clues to this. Philosophy apart, he writes on politics In two of his famous works—the *Republic* and the *Laws*—he sketches a political programme. What then is the essential point of this

political programme? "In his *Republic* and *Laws*", says Farrington, "Plato is wholly occupied with the problem of managing men, and not at all with the problem of the control of the material environment. Accordingly the works, if full of political ingenuity, are devoid of natural science."

We shall note here the main point of this political ingenuity, because that explains his hostility to science. Plato explains this point both in *Republic* and *Laws* and hence does not allow us to take any casual view of it. In spite of all the high-sounding words he uses elsewhere to ennoble "wisdom", when it comes to the brass tacks of practical politics of managing men, he feels the need of some deliberate falsehood. Let us see how he expresses it.

In the *Republic*, Plato visualises an ideal state with its governing class composed of two sections, called "the Rulers, in whom the governing authority is vested, and the Auxiliaries, whose duty it is to see that their decisions are enforced." The rest of the people are the farmers and other craftsmen—the toiling majority—who, in Plato's ideal, are concretely the slaves. On them the governing authority is to be enforced. Plato feels that what is needed to maintain such an ideal state is some deliberate falsehood. As he puts it, "Well, said I, how can we contrive one of those expedient falsehoods we were speaking of just now, one noble falsehood, which we may persuade the whole community, including the Rulers themselves, if possible, to accept?" He goes into much details of the nature of this "noble falsehood", which we have the scope here to quote only in part :

"I shall try to persuade first of all the Rulers and the Auxiliaries and after them the rest of the community, that all this upbringing and education they have had from us

was really nothing but a dream ; that really they were beneath the earth all the time··· until at last the earth, their mother, released them all complete into the light of day ···All of you, we shall tell them, are brothers ; but, when God was fashioning those of you who are fit to rule, he mixed in some gold, so these are the most valuable ; and he put silver in the Auxiliaries, and iron and bronze in the farmers and other craftsmen··· Therefore, the first and foremost task that God has laid upon the Rulers is··· to pay the most careful attention to the mixture of metals in the souls of the children ··· It has been foretold that, if ever the state should fall into the keeping of a bronze or iron guardian it will be ruined. That is the story. Can you suggest any device by which we can get them to believe it''? Plato holds that though it may be difficult to make the first generation accept such a lie, "perhaps their sons and descendants and eventually their whole posterity" may be persuaded to believe it.

In the *Laws* – the product of his maturest age – Plato is more explicit. He wants to explain the extreme undesirability from his political viewpoint of the conception of nature just as it is, *i.e.*, of precisely that achievement of the early Ionians, which makes them the path–makers of science and philosophy. Secondly, he pleads for the need of covering it up with consciously fabricated lies, and for this purpose even goes to the extent of admiring the petrified superstitions of ancient Egypt, only by scrapping which the Ionians achieve what they do.

Here is how he describes the horror of the view of nature just as it is :

"They say that earth, air, fire and water all exist by nature or chance, not by art, and that by means of these wholly inanimate substances there have come into being the

secondary bodies – the earth, sun, moon and stars. Set in motion by their individual properties and mutual affinities, such as hot and cold, wet and dry, hard and soft, and all the other combinations formed by necessity from the chance admixture of opposites – in this way heaven has been created and everything that is in it, together with all the animals and plants, and the seasons too are of the same origin, – not by means of mind or God or art, but, as I said, by nature and chance."

Such in brief is the way in which Plato sums up the intellectual achievement of the early Ionians. What interests him about it is only one point, namely its political consequence. From the point of view of his own political programme, this consequence is disastrous. As he describes it, "The Gods, my friend, according to these people, have no existence in nature but only in art, being a product of laws, which differ from place to place according to the conventions of the law-givers... This is what our young people hear from professional poets and private persons, who assert that might is right; and the result is, they fall into sin, believing that the Gods are not what the law bids them imagine them to be, and into civil strife, being induced to live according to nature, *i.e.*, by exercising actual dominion over others *instead of living in legal subjection to them.*"

It is a beautiful way of putting what hurts the political programme of Plato. While the early Ionians find it necessary to discard the Gods for the sake of taking the first step towards science, Plato—obsessed with his problem of managing men—sees the danger of viewing nature without the Gods, for it encourages the tendency to disown the legal authority of the rulers. What Plato says in the same work as a remedy against this danger is more startling. It is to bring up the young on lies. Thus, after trying to show that the life which

does not conform to his legislative programme is less agreeable than the one that conforms to it, he says :

"And even if this were not true, as our argument has proved it to be, could a legislator who was any good at all and prepared to tell the young a beneficial falsehood, have invented a falsehood more profitable than this, more likely to persuade them of their own free will to do always what was right ?"

He hopes that this should be possible, because it was possible to make people believe "the myth of Kadmos and hundreds of others equally incredible ..What an instructive example that is to the legislator of his power to win the hearts of the young ! It shows that all he needs to do is to find out *what belief is most beneficial to the state* and then use all the resources at his command to ensure that throughout their lives, in speech, story and song, the people all sing to the same tune."

But what is it that creates this tremendous confidence in such propaganda technique with which any myth or any falsehood can be successfully battered on the young mind ? It is, as Plato says, the example of the petrified culture of ancient Egypt. As he puts it :

"---What are the legal provisions for such matters in Egypt ?

—Most remarkable... They have established their norms and displayed them in the temples, and no artist is permitted in any of the arts to make any innovation or introduce any new forms in place of the traditional ones. You will find that the works of art produced there today are made in the same style neither better nor worse as those which were

made ten thousand years ago – without any exaggeration, ten thousand years ago.

—Very remarkable.

—Rather, I should say, *extremely politic and statesman like*...The Egyptians say that the ancient chants which they have preserved for so long were composed for them by Isis. Hence, I say, if only the right melodies can be discovered, there is no difficulty in establishing them by law, because the craving after novelty in not strong enough to corrupt the officially consecrated music. At any rate, it had not been corrupted in Egypt."

The extraordinary importance of this passage can perhaps be better understood if read along with a statement of Isocrates, a contemporary of Plato and one of the ten greater orators of Athens. He "cast a glance at the official religion of Egypt and detected its social utility. The Egyptian law-giver, he remarks, had established so many contemptible superstitions, first, 'because he thought it proper to accustom the masses to obeying any command that was given to them by their superiors', and second 'because he judged that he could rely on those who displayed their piety to be equally law-abiding in every other particular'."

We can now sum up the main historical facts we have so far discussed. In ancient Egypt there accumulated a great deal of technological experience and empirical knowledge in other forms. But all these remain under the veil of mythological-supernatural mystification. The early Ionians inherit this empirical knowledge. But only by tearing off the mystical veil on it they can take the decisive step to science and philosophy. Strangely enough, within a few centuries after them, a philosopher like Plato—with an incomparably improved philosophical equipment of his own—senses grave danger

in the intellectual achievement of the early Ionians. The danger is neither philosophical nor scientific, but very frankly political. In the *Republic* he starts talking of "one of those expedient falsehoods···which we may persuade the whole community...to accept". In the *Laws* he dreams of a legislator "prepared to tell the young a beneficial falsehood". As for the feasibility of making people accept such politically profitable falsehood, he hopefully cites the technique of the Egyptian law-givers. But perhaps finding it intellectually difficult to revert back to the mythological–supernatural mystifications in their ancient Egyptian forms, he seems to take a far more sophisticated precaution against the view of nature just as it is by commissioning his own fabulous philosophical talent and literary gift to preach a "lofty contempt for the material world with its ever-shifting phenomena", wanting men to view nature as "a foolish phantom of imagination". For about two thousand years after Plato, science remains on the whole eclipsed and what is produced as philosophy is viewed as puerile nonsense by Bacon and Descartes, who promise a fresh beginning in philosophy inspired basically by the same norm that makes the early Ionians the pioneers in science and philosophy.

Such are some of the basic facts of history, showing strange vicissitudes of science and philosophy. An analysis of these may enable us to understand not merely what happened in the past but also what is going on under the surface today, threatening both science and philosophy.

To begin with, why is the mystical veil on the view of nature in ancient Egypt? We have just seen how admirably Plato and Isocrates answer the question. Its main purpose is frankly political, *i.e.*, to keep the toiling masses fully servile to the law-givers. It renders help to the ruling minority to exercise authority over very large areas. We are still amazed

by what this mystical veil—the counter ideology—helps the Egyptians and Babylonians to achieve. "Gigantic works in brick or stone witness to the power of government to direct the co-operative efforts of vast populations. Ziggurats, Pyramids, temples, places, colossal statues–the dwellings, tombs, and images of kings and gods—apprise us of the organising ability of the great, the technical skill of the humble, and the superstitions on which society was based". The ruling class of such a society cannot allow science or science-oriented philosophy—nothing in short aspiring after a rational understanding of nature and man. It thrives on 'an official mythology, transmitted in priestly corporations and enshrined in elaborate ceremonial, telling how things come to be as they are".

For the beginning of science and philosophy, this spell of mythology has to be broken, and it is broken by the early Ionians. What enables them to break it is the basic fact of their belonging to a different socio-political climate. Here is an excellent description of it given by Benjamin Farrington :

"In Ionia, conditions in the sixth century were very different. Political power was in the hands of a mercantile aristocracy and this mercantile aristocracy was actively engaged in promoting the rapid development of techniques on which their prosperity depended. The institution of slavery had not yet developed to a point at which the ruling class regarded techniques with contempt. Wisdom was still practical and fruitful. Miletus, where Natural Philosophy was born, was the most go-ahead town in the Greek world... The information we possess makes it clear that the first philosophers were the active type of men, interested in affairs, one would expect to find in such a town---They were not recluses engaged in pondering upon abstract questions, they were not 'observers of nature' in an academic sense, but active

practical men the novelty of whose philosophy consisted in the fact that, when they turned their minds to wondering how things worked, they did so in the light of everyday experience without regard to ancient myths. Their freedom from dependence on mythological explanations was due to the fact that the comparatively simple political structure of their rising towns did not impose upon them the necessity of governing by superstition, as in the older empires."

In the Greek world, however, things change. The slave system becomes more and more firmly established. The implicit acceptance of the master-and-slave relation becomes the decisive element in Plato's political thought. Not that he sees no evil in his society; but these evils appear to him as not due to the master-and-slave relation but because of the incompletely rigorous enforcement of the rule of a privileged minority. He regrets the survival of free labour in some form in his society and he is annoyed with the problem of vagabondage or of the "sturdy beggars" — a problem that assumes such an alarming proportion in his times that his contemporary Isocrates sees in it even the danger of social revolution. But the only solution of such social evils that occurs to Plato is somekind of an absolute implementation of the power of the Rulers. For this purpose, he feels the need no doubt of strengthing the police force—the Auxiliaries of his ideal state. Apparently, however, he also feels that this is not enough. What is further required is the force of counter—ideology, the importance of which in policing the state is already well-proved in Egyptian society. Hence is his contempt for the intellectual achievement of the Ionians, or more broadly the contempt for science in general. With superb artistry and golden eloquence he wants us to be convinced of the virtual nothingness of the role of the toiling millions. The craftsmen and technicians are but poor

imitators of the Ideas or Forms already created by God. If the carpenter seems to make a bed, he does it only by imitating the Idea of the Bed made by God. Technology becomes subservient to theology, and philosophy becomes a tool of myth-making. The philosopher takes pride in this new function of philosophy because of its obvious political utility.

What makes philosophy turn away from science is thus not difficult to see. It is the demand for a counter-ideology necessary for stabilizing a sharply divided class society, which, in Plato's case, concretely means, the philosopher's consciousness being invaded by the ideological requirements of slave society. As Farrington very aptly puts, "Plato's thought was corrupted by his approval of the slave society in which he lived."

The slave society, succeeded by feudal society, brings in no relaxation in the political demand of the counter-ideology, which assumes only a new form – the Church and its dogmas. Any tendency to question the counter-ideology is ferociously suppressed by the Inquisitors and so science remains almost totally eclipsed by the shadow of religion. There is no question of the philosophers returning to science. The only task the philosophers are left with is that of the analysis and rationalisation of the dogmas.

And then, about two thousand years after Plato, the very foundation of the old society requiring the political support of the mythological and metaphysical mystification of reality, is shaken up. Science is called upon to play a decisive role in the transformation of society, under the leadership of merchants, navigators, manufacturers and statesmen, who organise themselves into a gradually growing powerful class—the early progressive bourgeoisie. Here is

how Engels describes the new interest in science taken by the new forces of society. "Moreover", says he, "parallel with the rise of the middle class went on the great revival of science; astronomy, mechanics, physics, anatomy, physiology were again cultivated. And the bourgeoisie, for the development of its industrial production, required a science which ascertained the physical properties of natural objects and the modes of action of the forces of Nature. Now up to then science had but been the humble handmaid of the Church, had not been allowed to overstep the limits set by faith, and for that reason had been no science at all. Science rebelled against the Church; the bourgeoisie could not do without science, and, therefore, had to join in the rebellion."

Thus is created a new situation altogether in the old tension between science and social organisation. After the brief Ionian dawn, in ancient Greece–and more particularly in medieval Europe–ideology remains at the mercy of the social organisation. From now on, social organization is on trial before ideology in its new vigorous form, namely modern science. We shall see how far-reaching are the consequences of this. Though the bourgeoisie helps to bring in modern science, the progressive onrush of modern science eventually makes the rule of the bourgeoisie or its class domination in its latest form the most harmful wastage of man's knowledge and power. It demands in short the abolition of the very mechanism on which society thrives beginning from days of the ancient river valley civilizations. It is the mechanism by which the toiling majority is ruled over by a parasitical minority.

Already during the days of the birth of modern science, there are people with sufficient foresight to warn the ruling class of the impending catastrophe coming from the same forces it is going to release. In 1669, Bossuet, in his funeral

oration upon the widow of Charles I of England, prophetically describes the ultimate results of the "democratisation of truth" rightly considered by him as the essential precondition for modern science. "Every man", he says, "constituted himself a tribunal wherein he was the arbiter of his own belief...Hence is was very predictable that, there being no further limit upon licence, sects would infinitely multiply, and stubbornness would be invincible... God, in order to punish the irreligious waverings of these folk· abandoned them to the intemperance of their mad curiosity... It is not at all astonishing that they thereupon lost respect for majesty and for the laws, nor that they became factious, rebellious, and intransigent. You unnerve religion when you meddle with it, when you deprive it of a certain gravity which alone can hold populations in check."

This warning, rightly understood, is a warning against the possible consequence of science for class rule as such and therefore also against the ultimate destiny of the bourgeoisie itself. But the rising bourgeoisie has apparently no patience for such an advice· For a brief period at any rate, it seems in science a powerful weapon to forge its own political and economic power, and hence relies recklessly on it in its rebellion against authority and establishment. The founders of modern European philosophy see in science the way out of long stagnation.

It is not the place for us to try to go into the full story of the transition from medieaval to modern period. But it is essential to note one point, because of its importance for understanding subsequent history.

Without undermining the role of science in bourgeoisie revolution, it is wrong to think that its success is due only to the revival of interest in science. Secondly, though the rising bourgeoisie does provide the revolution with its

leadership, it is impossible to believe that the merchants, navigators, statesmen and manufacturers of the period themselves fight it out. The actual fighting contingent for the revolution is drawn only from the working people. As Engels points out, "Anyhow, had it not been for that yeomanry and for the *plebeian* element in the towns, the bourgeoisie alone would never have fought the matter out to the bitter end." Accordingly, to draw in this fighting contingent, the rising bourgeoisie has to represent a much wider social interest than that of its own class. "But", says Engels, "side by side with the antagonism of the feudal nobility and the burghers, who claimed to represent all the rest of society, was the general antagonism of exploiters and exploited, of rich idlers and poor workers. It was this very circumstance that made it possible for the representatives of the bourgeoisie to put themselves forward as representing not one special class, but the whole of suffering humanity."

With this analysis of the role of the toiling masses in the transformation of the medieval world, we can see an essential factor of the new philosophy announced by Bacon and Descartes. It is the vision of human freedom–not the freedom of one class but that of the whole humanity. The main purpose of science, they feel, is to develop new insight into nature, and–as philosophers–they argue that this insight is convertible into mastery over nature. Knowledge is power in the specific sense of material human power essential for human emancipation. This is a new orientation to knowledge altogether. As J. D. Bernal, one of the greatest scientists of our age, explains :

"It was changed from being a means of reconciliation of man with the world as it is, was and ever will be, come doomsday, to one of controlling Nature through the knowledge of its eternal laws. This new attitude was itself a product of

the new concern with material wealth and brought about a renewal of interest of the learned in the practice of the trades of the artisan. In this way the Renaissance healed, though only partially, the breach between aristocratic theory and plebeian practice which had been opened with the beginning of class society in early civilization and which had limited the great intellectual capacity of the Greeks ......Indeed, the challenge to ideas that had been accepted for many centuries could only have been made at a time when the whole foundations of society were in question."

With this questioning of the whole foundations of society, the philosophers get inspired with a new kind of optimism altogether. Bacon speaks of man becoming "the propagator of man's empire over the universe, the champion of liberty, the conqueror and subduer of necessities"! Descartes speaks of man becoming the 'masters and possessors of nature"! How audacious all this must have sounded about three hundred years ago. Yet how prophetic has all this been already proved. Masters and possessors men astonishingly are of the physical nature today, and the rate of progress of the further extension of this mastery has indeed become staggering. A new age is already within the reach of human vision. It is an age of a virtually endless mastery over physical nature based on an ever-deepening understanding of it and of its laws. It is in short the vision of an age not only of very great achievements of science but also of the entire benefit of this going to meet the requirements of humanity as a whole.

But all this is only one side of the picture. There is also another side of it, which must not be overlooked. Let us not forget that in spite of the promise of such an age, man remains confronted by "the aotuality of a divided world with greater poverty, stupidity and cruelty than it has ever

known." There is even the threat of the total extinction of mankind. It needs today perhaps no more than the crazy act of pressing a few buttons here and there to remove from earth all traces of man–in fact of all living beings. So colossal indeed is the destructive potential attained by the progressive perfection of the physical and biological sciences! Much of the information about this is of course kept "secret" and it is forbidden even for the working scientists to know the actual purpose they are engaged to serve. Nevertheless, the little that somehow or other trickles out of "security measures" locks sufficiently appalling.

Such a threat to mankind thus appears to come from the same knowledge and mastery of physical nature in which the founders of modern philosophy so gallantly saw the hope for very great human future. Is there then something wrong about the way they look at science?

The question is being answered with an ever-increasing clarity by recent history and therefore also by the philosophers and scientists with the right understanding of history. Modern science is brought into being by the bourgeoisie which needs science for the great revolution in the mode of production and, which as required by it, has to organise a stupendous social revolution. The revolution succeeds, thanks to the participation of the toiling people, who, through this revolution, are transformed into the organised working class of the modern world. Thus come into being modern science, and, along with it, the modern working class, both with the historic mission of not only making the capitalist epoch obsolete but also of finally overthrowing it in favour of socialism.

"If capitalism", says J. D. Bernal, "first made science possible, science in its turn was to make capitalism unnecessary". We do not have the scope here to go into the details of

this process. But it is necessary to note why science becomes increasingly incompatible with capitalism. While science opens rapidly growing possibilities of an age of hitherto undreamt of abundance, capitalism–driven by its inner logic of profit–hunting for a negligible minority owning the means of production–finds itself obliged not only to keep the productive forces crippled but also to see that a large and growing part of the product–instead of meeting genuine human needs–is channelled to useless, wasteful and positively destructive purposes. The clearest example of this is the militarization of science. Here is how J. D. Bernal describes it :

"It is the same demand for maximum profit that has given, in recent years, the heavy bias of technology and science towards military uses. Profits there are enormous : the public pays without asking awkward questions, and the resulting goods do not clog the market. They can be expended in wars, or, if that fails, scrapped in a few years as obsolete. The demand for them is also reinforced by every means of propaganda needed to keep up war fever and justify military expenditure. One consequence of this has been the militarization of science, with all its consequences of secrecy, screening and witch-hunting. In one way or another, directly or through government agencies, science in the capitalist sector of the world has come under the control of the small number of big monopoly firms".

This is an eloquent commentary on the incompatibility of science with capitalism in its last desperate phase If capitalism hopes to survive at all, it has to mobilise all its resources to the most massive misuse of science–to convert it into a hired killer as it were working for a handful of profit-hunters, the monopoly capitalists.

The danger of the immediate present must not be minimised. At the same time, there is no real reason to surrender

to despair, There is a limit beyond which even the worst conspiracy of misusing science can succeed. The deterrents come from the same decisive forces that are brought into being by capitalism itself. These are science and the strength of the working people. We shall have a few words on both, because these have important implications for understanding the very grave responsibilities of the philosophers today.

First : science. The physical and biological sciences have attained today such a degree of sophistication that it often proves difficult even for the working scientists to assess the exact amount of power these can wield. And the progress continues and the rate of this progress becomes almost incalculable. If therefore this power of science continues to be mobilised from destructive purposes, the destruction can stop nowhere short of the total annihilation of our planet. Eminent scientists have already made some calculations of this, though these prove obsolete sooner or later. The details of all this do not concern our present purpose. What concerns us is a simpler question. How far can the profit-motive of the monopoly capitalists actually lead them to ? Can they go as far as to opt for a dead world in which their balance-sheets lie buried under heaps of corpses–their own corpses as well of others ?

But the monopoly capitalists alone are not to answer the question. Besides them, there are working peoples–inclusive of the working intelligentsia–who have already freed a vast area of the globe from the fetters of the capitalist system. This free world–the real free world–shows how much man's mastery over nature can really mean in terms of the real welfare of real men, women and children–all this within the brief period of about half a century and in spite of suffering the most colossal devastation of the second world war and in spite of the wastage on the armament necessitated as a

deterrent against the continuing threat of a more devastating war to annihilate them.

The most gigantic propaganda machinery is of course used to conceal all this from the working peoples of the capitalist world and of the developing world. Shameless techniques are being used to cheat them of their rightful claim to the proper use of science. Scientific method itself–particularly of mass communication and education–is being used to retard or deflect the course of history. Enormous finance is mobilised to dig up religious and magical superstitions of the past, with which to opiate the working people, to make them forget what science can mean for man. Notwithstanding all this, however, there is the growing consciousness of the working people, and along with it the sharpening of the crisis of the effort to keep the possibilities of modern science reconciled to the fragmented social frame of private interest and exploitation.

What in this situation is the philosopher supposed to do? It is no use denying the influence of money and political power on him. The fabrication of what Plato called "expedient falsehood" in new and newer forms continues to be a lucrative proposition today. Besides, there is the threat-sometimes subdued, but often open-against the philosopher's tendency to describe the world as it is, without alien addition. As Burrows Dunham, one of the most eminent American philosophers of this century, so clearly puts, there is the effort to "force upon the thinker the odious choice between rewards for telling lies and punishment for telling the truth".

In the philosophical world today, there are indeed some who have chosen the former alternative. What brings hope, however, is the fact that there are also others who have braved and are braving the second alternative. ●

Science and Politics

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"Now there are six", said the Columbia Broadcasting Corporation dramatically in announcing the explosion of a nuclear device in India on the 18th May, 1974, "India has joined the exclusive nuclear club".

That was an exaggeration. It would be more accurate to say that India has crossed the nuclear threshold. But, unlike the members of the nuclear club, India has disavowed any intention of going in for nuclear arms. "We remain", said the Prime Minister in her first statement after the explosion, "deeply committed to the peaceful uses of atomic energy".

There is little doubt that the explosion of a nuclear device by using the most advanced methods is a landmark in the progress of Indian science. The attitude of the Indian public towards the study of science has changed considerably since the beginning of this century.

In my childhood, specialisation used to start early—far too early. I was hardly in my teens when, in the fourth form, I had to choose between groups A, B & C, that is between Mathematics, Science and History. Among the students the vast majority plumbed for History. Nowadays

the tendency is in the reverse direction. There is a scramble for Science and Mathematics, and there are fewer candidates for Literature and History. Not that all those who take science are fired by a pure zeal for it or are following Pope's exhortation :

> Go, wondrous creature !
> Mount where Science leads.

Most of them feel that in these days of industrialisation they have greater chances of getting a job with a science or mathematics degree than with a degree in history or literature. And who can blame them ? Educated unemployment continues to be a curse in India. This has been so, especially in Kerala, and it is one of the reasons for its political instability, which seemed almost chronic until the present Chief Minister, Mr. Achutha Menon, came to the scene.

In view of the present premium on science, there is not much danger that our future politicians will be altogether ignorant of it, as some of my generation were apt to be. To learn science at school or college, however, is one thing ; to keep up with the latest developments in science is another. The question may be asked whether the politician is sufficiently well equipped to take complicated decisions involving science and technology.

The politician may well retort : is the scientist well equipped to take action affecting not merely the welfare of man but the future of humanity ? Can he, indeed, be trusted to give absolutely dispassionate advice even on scientific matters ? One has only to remember the controversy between Dr. Teller and Prof. Oppenheimer in the USA in order to realize how even the most distinguished scientists can differ in regard to their assessment of such a vital matter as the effects of nuclear bombing. Even scientists are human and

cannot be expected to be altogether free from human prejudices. Not to mention names, some eminent scientists of leftist proclivities in India and England were disposed to give credence to China's wild accusation in 1952 that the Americans had resorted to bacteriological warfare in Korea.

Our parliamentary system is based on a healthy suspicion of infallibility of experts. A famous judge divided the witnesses in courts into three classes, liars, damned liars and experts. There is a similar saying in the field of economics: lies, damned lies and statistics. Perhaps such statements reveal the ignorance of the layman as well as his jealousy of the expert. In any case, the political system, which we have inherited from Great Britain, means essentially a Government by amateurs as distinct from professionals. In the Soviet Union, on the contrary, Ministers are generally experts in their own field. For instance, in my time in Moscow, the Minister for Railways was one who started service as a Railway Guard and rose gradually to the top; and nothing he did not know about the railways was worth knowing. But in the USSR ministers are no more than heads of departments; all vital decisions on policy are taken in the Presidium of the Party. Under our system, a head of a department must have knowledge, but a minister must have wisdom. Not that these properties are mutually exclusive; yet there is a distinction between them. One recalls the lines of T.S. Eliot:

> "Oh, where is this Life we have lost in living?
> Where is the Wisdom we have lost in Knowledge?
> Where is the Knowledge we have lost in Information?
> The cycle of heaven in twenty centuries
> Brings us farther from God and nearer to the dust".

These lines are specially applicable to the present plight of humanity, which may indeed be reduced to dust by a

nuclear war. Dr. Pauling, who won the Nobel Prize for Science as well as for Peace, has pointed out that a single Bikini bomb, known as the 20 megaton bomb, exploded over New York, can kill 10 million people ; and 500 such bombs, or 10,000 megatons, would be enough to kill nearly everyone in the USA. And at that time, the stockpile of the USSR came to 80,000 megatons. The USA's stockpile came to 240,000 megatons, but that makes no difference because it makes little difference whether a man is killed once or three times !

The controversy whether India should or should not join the nuclear club throws much light on the respective roles to be played by the scientist and the politician. This controversy was provoked by China's explosion of a nuclear bomb. Dr. Bhabha, whose contribution to the cause of Indian science cannot be over-emphasised, expressed his opinion that India was in a position to produce an atom bomb ; and he very properly left it there. There are, however, some people who seem to make no distinction between 'can' and 'should' ; they see no reason why, if India can produce a nuclear bomb, it should not. But if a man starts doing all the things he can do or wishes to do, he will soon find himself in jail or in the lunatic asylum. Similarly, if a nation starts doing all the things it can do, the results will be national bankruptcy or war. The decision that India should not manufacture the atom bomb was taken by balancing a variety of considerations, political, military, economic and even spiritual. At the same time India refused to sign the Non-Proliferation Treaty, sponsored by the USA, the USSR and the United Kingdom, because India felt that it was highly discriminatory. Moreover, she wished to keep herself free to carry out an explosion for peaceful purposes. This was primarily a political decision.

Jawaharlal Nehru knew the horrible potentialities of that "diabolical weapon", the nuclear bomb, and carried on a crusade against it. At the same time, he realized the enormous potentialities of nuclear energy for peaceful purposes. He recognised that it was particularly useful for under-developed nations which, within a few decades, had to make up for centuries of backwardness.

The backwardness of India until the middle of this century was due to the fact that it stood outside the stream of the industrial revolution: it had to be content with the crumbs which fell from Britain's table. It was the industrial revolution which enabled Western Europe to forge ahead of the rest of the world and, to a large extent, control it. India was, and is, determined not to be left out of the present technological revolution as well. That was primarily the reason for our decision to carry out a nuclear explosion. In this matter the scientist's role was no more than that of an adviser, or consultant.

If the scientist should not encroach on the sphere of the politician, nor should the politician trespass on the sphere of the scientist. The most flagrant examples of political interference in science took place in Russia in the time of Stalin. Stalin claimed the last word not merely in political and ideological matters, but in military strategy and even on scientific problems; and some scientists, or pseudo-scientists, like Prof. Lysenko flourished by playing up to his whims and caprices. This tendency was reversed soon after he passed away. Lysenko has been decisively debunked.

No Government, however, should be content with an attitude of simple neutrality towards scientists. It is incumbent upon the Government to foster science in every possible way. In its own interests, Government should safeguard the prestige of the scientist as the apple of its eye.

In the Soviet Union, no profession enjoys such high prestige, let alone emoluments and other amenities, as that of the scientist, his only competitor being the ballerina.

The politician and the scientist have separate, though complementary, roles to play in the development of society. A scientist cannot play the politician without detriment to his scientific character, nor need the politician don the mantle of the scientist. But it is essential that a politician, whether he is a student of science or not, must have a scientific temper. By this term, I mean the spirit of free inquiry, open-mindedness and detachment, or, in other words, a combination of intellectual integrity and mental serenity. In this, as in other respects, we cannot have a better model than Jawaharlal Nehru. He was distinguished by his scientific temper. But he had more than a scientific temper; he also had the temper of a poet, an artist, a lover of nature and a man of action who was also a man of dreams.

Whether a less versatile and more ruthless administrator was not what India needed in the early years of its independence is an open question, but no one could have charted the course for India better than Jawaharlal Nehru. To move away from this course would be to float adrift in an even more turbulent sea of troubles than the one through which India has passed since she became free.

Science and Literature

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I have not studied science, not even at school. Science as a subject was just being introduced in the school curriculum when I was a student of the 6th standard, and the only lesson I remember having been taught was, about the properties of water, that water flows, that it flows downward and that it keeps its level even. This is all the science I learnt, at school. You will naturally ask, why I, a man knowing nothing of science, and whose main pre-occupation is writing stories and novels, should talk about science and try to correlate science with literature.

Then again what has science to do with literature, anyway ? There seems to be hardly anything in common between them. Science deals with facts, with objective reality, with the investigation of laws governing the physical world. Literature on the other hand deals with human emotions, with joys and sorrows and human aspirations ; a writer is a creature of instinct and emotion and imagination, whereas the study of a scientist is governed by reason in which there is no place for sentiment or flights of fancy and imagination. A writer's art is the product of his emotional apprehension of the world and as such can be highly subjective, whereas the

work of a scientist has to be objective to the core. No two spheres could be more different from each other

Yet, I would venture to say, they are not antagonistic to each other, on the contrary, science is complementary to literature. Both deal with Truth, and neither of them can depart or deviate from it except at its peril. Even though his mode of apprehension may be different, the writer cannot present a false picture of life. Of all the demands that are made on the writer's art, the foremost demand is that what he writes must be authentic, and true to life. Falsehood is as reprehensible in literature as it is in science. Of course the story that a writer writes need not be based on an actual incident. It need not be actual, but it must be plausible. That which does not conform to life's reality fails to carry conviction with the reader and is very often rejected. And science helps the writer in having a fuller and a more correct understanding of the world and even of human nature. The treasure-house of knowledge, enriched by science is as valuable and illuminating for the writer as it is for any one else. No writer can write about the world of facts in an arbitrary manner. Just as, while writing a novel about medieval times, it is imperative for me to know the customs, manners, modes of dress and behaviour and the outlook of the people of those times, it is necessary for me, while dealing with the world of reality to represent it correctly and not to indulge in inaccuracies, or misrepresentations. In the writer's world too, the sun must rise in the east and set in the west and not the other way round. The earth too must move round the sun and not the other way round. The fact that the writer lives in a world of instinct and emotion does not mean that he has nothing to do with reason or with the objective understanding of reality. Even the most imaginative of writers cannot wish away the world. The world will exist

and will continue to exist. And if the objective world is a reality for him, then the knowledge of the laws operating in this objective world is also relevant to his pursuit. In fact he must present the objective world in much the same light as it is presented by the scientist.

Over the last two centuries or so science has held the key to human knowledge. Its discoveries have deeply impressed us while its inventions have greatly affected our material life. So much so that we have begun to regard it as a trustworthy source of knowledge. Under the influence of science we have become sceptical about any knowledge gained through means other than scientific ones, and regard only that knowledge as reliable which can be tested and verified. This outlook goes by the name of rational or scientific outlook. Of course, in times of acute personal crisis, or in a state of nervous tension, a person may lose his reasoning faculty and may go to mystics, sadhus, astrologers and the like for help and guidance. On the eve of an election a politician may go to an astrologer, and a panicky mother may take her ailing child to a sadhu, but that is when our reasoning faculty is paralysed. In normal situations, we prefer to be guided by those who have specialized in the scientific method of enquiry. You and I have heard of numerous incidents where miraculous cures were effected, or the future prophesied with remarkable precision, or where a person has had a prophetic dream, but more often than not, we suspend our judgement till a proper scientific enquiry has established the genuineness of these occurrences or discovered the natural laws operating behind them. The other day when someone told me that there is a lot of scientific investigation going on in the field of extra sensory perception. I felt glad and relieved. So deep is our reliance on scientific mode of enquiry that we are prepared to believe in any phenomenon if tested

and found valid by science. This is how science has influenced our thinking.

Where then does literature come in ? Literature deals with man, his situation, his joys and his sorrows. But under the influence of science a change has taken place in our attitude towards those forces which affect human life and which either reward or frustrate his endeavours. In the past, people had implicit faith in divine dispensation, and in the dominant role of the supernatural powers in human affairs. To-day, man's life is viewed as independent of the operation of supernatural forces. Under the influence of science we seek the causes of man's joys and sorrows within the framework of human society itself. A writer to-day views man's affairs more against the background of social forces, of socio-economic causes to his situation than against the background of divine or supernatural agencies. This does not mean that everything has become explicable and clear in human affairs. There is much that is bewildering, much that is confusing and inexplicable, but the habit of attributing all happenings to supernatural forces, has gone. The whole superstructure of belief built on the basis of divine dispensation has crumbled under the impact of science. The concept of sin and punishment, of divine retribution has, likewise, been given up. There is a story told about the fire of London which broke out in the 16th century. It was a devastating fire, they say, and it was followed by on outbreak of a plague epidemic. The Puritans attributed the occurrence of these two misfortunes to the two theatres in London, which had become popular among the people, and which according to the Puritans were hot beds of vice and corruption. The verdict of the Puritans was that fire and plague were God's punishment on the people of London for harbouring and encouraging the theatres. Had it rested there, the matter would have been

treated as mere prejudice of the Puritans. But in those days there lived a scientist too in the city of London. And some religious people attributed the plague and the fire to God's anger over the activities of this scientist whose investigations went against the principles of the Christian faith. The story goes that the Parliament deliberated over the issue and decided to send the scientist into exile. This punishment was carried out, and it is said that the scientist died on board the ship, on his way to Jerusalem.

Such an attitude towards science is unthinkable now.

Similarly the belief that man's material position in life is largely determined by the Almighty, that a millionaire is a millionaire and a beggar a beggar because God willed them to be so, is a concept which has become obsolete with the writer today. A poet once wrote:

> "*God made them high or lowly*
> *And ordered their estate*".

Man's estate is not ordered by Providence, but by economic, social and political forces and his role in society. If a story or a poem written today emphasizes the old concept of sin and virtue or speaks in terms of the new and of the deeds of past birth, it will not carry conviction with the reader. The outlook of both writer and reader has changed. However anarchic and rudderless human affairs may be, the writers by and large, view them to-day as largely of man's making, and not the result of Divine Ordinance. Nowhere will you find a black poet of South Africa accepting white supremacy as a matter of divine dispensation. In India only a very obscurantist writer steeped in medieval thinking will justify the position of the untouchable in our society as divine dispensation. However loud the protestations of the orthodox Brahmins may be, the writer finds it hard to accept

the position of the untouchable either on moral grounds or on grounds of social justice or as a matter of divine dispensation. This change in outlook, has, to my mind, been largely brought about by science.

To-day a poet will not say, as Kabir, for instance, had said in the 15th century (if I am quoting him rightly) :

कबीरा तेरी झोंपड़ी गल कटयन के पास
करनगे सो भरनगे तू क्यों भयो उदास

"*Kabir, your house stands next to a butcher's shop. But why do you grieve ? the butcher will reap the reward of his misdeeds in his next birth.*"

Of course, the writer, as a humanist, has always, intuitively sympathised with the underdog, and raised his voice against discrimination and injustice, but under the influence of science he has rejected that philosophy built on the concepts of sin and virtue and of divine dispensation, which demanded unquestioning acceptance and submission from the individual in the past.

The keen eye of science has penetrated deep, not only into the working of the physical phenomenon, but also into the laws that govern human relations in society. An objective understanding of the laws of social development and change serves as a corrective to the writer from falling a prey to prejudice and superstition. Social sciences have revealed, for instance, how in the past, religion has been used to uphold political domination and even tyranny. In our society, killing a Brahmin was regarded a sin, as also a grave social and political offence. Much has been written in the Puranas on this subject. It clearly indicated that somewhere religion was

hand in glove with the state and this dictum was formulated to uphold the privileged position of the Brahmins. In Aristotle's 'Poetics', a line occurs, where while discussing the characters of tragedy, he says, "A woman may be good, a slave can never be good." This observation too reflects the state of social relationships as they existed in Greek society, sanctified by religion and traditional belief. In the same way the privileged position of the rich has been sought to be justified on the ground that their riches are due to the good deeds of their previous life, and that any questioning of this belief would be a denial of God's justice.

The scientific outlook has removed from our minds many of those mental cobwebs which had been created by superstition, blind faith in religion, etc. It has perforce influenced the writer to view reality more closely, more objectively ; and to seek the causes of human sorrow and suffering within human society itself. This is another valuable contribution of science to literature.

Of the great thinkers who have greatly influenced our thinking in modern times, Karl Marx is certainly one. And he is very often called a social scientist. It is because he tried to investigate scientifically the laws of social development and change. And his discoveries in this realm have deeply influenced the thinking of intellectuals all over the world, including writers. His findings help us view human affairs in a new light. Why are there inequalities in society ? Why do wars break out ? What is it that causes hunger and poverty ? The social scientist reveals to us the causes working behind these and other social ills. The knowledge of the working of the social phenomenon enables us to seek solutions to social problems more consciously and with a clearer sense of direction.

I shall cite an example and try to show how the scientific approach to the laws of social phenomenon has changed the writers' outlook in social problems.

Charles Diekens, the great English novelist, had profound sympathy for the poor. He has given very vivid descriptions of the life of the suffering people. But when it came to finding a solution to their misery, he could either suggest a 'change of heart' in those peop'e who caused the suffering, or brought on to the scene a benign gentleman, whose generosity and sympathy would bring relief to the suffering characters. In Hindi literature, our writers too, including Premchand have sought similar solutions. In Premachand's earlier novels, the landlord, on seeing the light, either turns a 'Sanyasi' or becomes a philanthropist. But that was invariably an idealistic solution to a practical problem, and very often left the reader unconvinced: You cannot resolve a social problem by offering a solution which holds good only in terms of individuals. All the landlords of India would not turn 'Sanyasis' or philanthropists. However remarkable the transformation of an individual may be, it will not change the basic situation. Hence a solution other than 'a change of heart' is needed. This does not mean that Dickens and Premchand were not great humanists. The social scientist will tell us about the class character of society and give a new perspective to the understanding of social phenomenon. Their humanism is undoubted. The scientific outlook gives a new dimension to humanism. That which was previously felt intuitively by the writer, is now more comprehensively viewed by him in terms of cause and effect. The heart of the writer has invariably been in the right place, but now with his sympathies, tempered with awareness of the laws of social development and change, his treatment of life will become more authentic and objective and more comprehensive. And consequently his

contribution to the cause of social progress will become more effective.

I referred earlier to the African poetry of protest. How is it that more and more writers are being drawn into the vortex of struggle, either for the liberation of their countries or for a more just and equitable social order. It is not a mere coincidence that some very eminent poets of our time have been actively involved in the struggle of their peoples for a better social order. Pablo Neruda, Agostino Netho and many others have been in the midst of events. You will say that this is not a new phenomenon that writers have all along been patriotic and fought for their countries against the enemies. I would maintain that it is not a question of patriotism or of emotional involvement alone. There are instances where writers have fought and died in wars in which their own countries were not involved. Christopher Candewell and Ralph Fox, two English writers, died in the civil war in Spain, fighting on the side of democratic forces against Fascism. During the 2nd world war many an Indian poet had hailed the heroic resistance of the Red Army against Hitler's hordes. And how many of us have been moved by the epic struggle of the Viet Namese people against foreign intervention and identified ourselves with their cause. The writer to-day has shed off much of his exclusiveness and is identifying himself more and more with social causes. He has a more objective understanding of the forces at work in society, his humanism is tempered by a scientific appraisal of society and is touched by a new outlook on life and society.

Moreover a scientific approach cannot be a fatalistic approach. Science is the disinterested pursuit of knowledge, but this pursuit has involved centuries of painstaking investigation as also the collective effort of generations

of scientists. Behind every discovery and invention there is the silent and selfless labour of hundreds of scientists and scientific workers. Scientific investigation is a continuous process. If not directly, at least indirectly, it carries a lesson for all those who wish well of human society, that given an objective approach to the complexities and inner contradictions of social life, it is possible to overcome them and usher in an era of peace and tranquillity for mankind, free from wars, hunger, poverty and disease and exploitation of man by man. It fills the writer with a sense of optimism and hope too that problems can be overcome and solutions found. Great literature has always been edifying, it has been characterized by faith in life and has always instilled hope and confidence in man. The scientific spirit strengthens this confidence, in the large context of society. If man can walk to the moon, he can surely overcome the problems of hunger, poverty, wars and the like that beset humanity to-day. The cure for cancer has not yet been found, but the scientists have not given up their efforts. Science puts the writer in a frame of mind of faith in human endeavour, instead of breeding cynicism or fatalism in him. And it impels the writer to shed off his exclusiveness and identify himself with the life and destiny of mankind.

Some of you may be silently laughing at this panegyric being sung by me in honour of science. And that also at a time when, with the help of scientific knowledge, such weapons of destruction have been invented which can wipe out the whole of humanity from the surface of the earth in a matter of a few hours. Some of you may say that the increasing potential of scientific knowledge, particularly in its applied form, is corroding the very faith in life for which literature stands. Science and technology have so accelerated the pace of life that human beings cannot cope with it.

The tensions of modern life are said to be largely due to scientific inventions. The new problems of radiation, air-pollution, etc., are the direct results of the technological advancement ; And consequently, the quotient of human happiness is decreasing. You may say, science might have increased our knowledge or even strengthened man's control over the forces of nature, but it has not added one iota to the content of human happiness; that science is letting loose forces which are increasingly getting beyond human control. A civilization at once monstrous and pitiless has set in with the advent of science. So on and so forth.

In answer, I can only repeat what has been said by many a wise man before, that science is not an independent entity; that it does not operate on its own volition in human society. It is an instrument of knowledge and can be used for good or ill by those who wield this instrument. When a scientific invention is used to increase the profits of the few and the misery of the many you cannot protest against science but only against the wrong use to which it is being put. Modern technology has advanced to the extent that a whole factory can run automatically, with only one or two hands to control its operation. This is a challenge to society. If this new technology is not used rationally, in the interests of society, but only in the interests of the few, then it will render thousands of workers jobless. But if used rationally, it will reduce the physical exertion of many workers, give relief to them in their back breaking toil, and promote greater happiness in society. That way, every new invention of science poses a new challenge to society. Who does not know that with new technology, production can increase to the extent that not a single individual need go hungry, yet, who does not know that thousands of tons of foodgrains are thrown into the sea in order to keep the market-prices high. The same can be said

about nuclear or thermo-nuclear energy. It makes it all the more imperative for a writer to become more and more aware of the forces that are at work in society and identify himself with those forces that stand for human welfare as against those that do not. Science is not an independent agent in human affairs. The writer has to view scientific knowledge in the context of society, he has to link it with the question of human welfare, and since human welfare is not merely a pious wish but something for which human beings have to struggle, he, perforce, has to view the role of science, in the context of the struggle for human welfare. It may appear that science has, under its influence, restricted the scope of poetic imagination, that it has no value for the poet who 'flaps his luminous wings in the void'. If that were really so, it would be unfortunate. I do not believe that the world of intuition and imagination has to be forsaken by the poet for the world of fact and reason. Ideals, intuitive insight into reality have as important a place in literature today as they had before. Only, they have to be blended with the consciousness of objective reality, not divorced from reality Purely speculative literature proves one-sided and barren.

'सर्वे भवन्तु सुखिनः, सर्वे सन्तु निरामयाः'

is an ideal which we all cherish. Poet's still dream of the Golden Age still inspires the reader. Tagore's strivings for union with the Infinite, with the Universal Spirit, still takes us out of ourselves, and opens new vistas before us. Science has only made us conscious of the need to correlate ideals with reality, not to reject ideals but to have a balanced view which can hold both reality and ideals together. both reality and ideals together. Science has not stifled intuition or imagination. It has only given a new dimension to the

writer's awareness. The scientific outlook is that balancing faculty which does not permit the writer to withdraw either into superstition or into the world of subjective sensibility. It helps the writer retain a balanced perspective.

Over the last century or so, literature generally has been coming closer and closer to reality. The tendency to escape into a dream-world or to obscurantism has been growing less and less. An attitude of objective, realistic appraisal has been gaining strength. Whenever the writer has given up his faith in the scientific outlook he has invariably lapsed into obscurantism. It is not coincidental that those who are writing obscurantist stuff to-day are also those who are condemning science most of all. The so-called modernists who swear by one's personal sensibility and view the world as having reached a dead-end, invariably blame science and technology. They reject objective appraisal, reject reason, reject the role of forces that mould and determine social life, and live in the world of their own making.

However, while welcoming the influence that science exercises in the sphere of literature, I still maintain, that the last word rests with literature and not with science. Literature mirrors life, it reflects human reality and is committed to man. Science is a means, a disinterested pursuit of knowledge. Having a distinct social function. literature is involved with the question of human happiness, Even scientific inventions and scientific knowledge will be judged by the writer in the larger context of human happiness. The writer is the conscience-keeper of society. Literature deals with values, it creates values, it is concerned with concepts of good and evil, justice and injustice. With all the contribution that science makes to our knowledge and understanding, the writer's world still remains a bigger

world, because it embraces not merely the world of sense but also the world of spirit, not only the reason of man but his entire being, all that exists in the universe is still the domain of literature.

Science and Health

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The evolution of man has passed through stages of feeding on pickings, hunting, and agriculture to that of technological advancement. In the pre-historic period, a great many men and women died young. The average age of man was round 30 years. At the present time in many developed countries, an average person can look forward to live for 70 years. Man differs from other animals, particularly in requiring long period of care in childhood, to ensure an average life span. Healthy living involves disciplined behaviour, purity of water and food, and control over a large number of diseases caused by a variety of organisms. As we shall see, control over these has been achieved over the years through growth of science. In no other field of human endeavour has the growth of science such a profound effect as in the development of health sciences.

Medicine has developed through a number of overlapping stages until it acquired status of science. For long medicine was not a science, but rather a scrap book of information. Most of what was valuable had been discovered by people who were not primarily doctors. Medicine appropriated everything from every source that could be of slightest use to anybody ailing. In all animal kingdoms there is an instinctive

reaction to injury or sickness. If a dog is hit, he limps away and rests; if it is wounded, it licks the wound clean. The early man must have done similar things. Man continues to learn through methods of trial and error. The earlier approach to disease was mostly empirical and shrouded in superstition. Disease was thought to be caused by invisible spirits that required application of magic to be warded off. Natural calamities like droughts and floods were believed to be caused by wrath of Gods. Even to this day faith healing is far from dead. There is hardly a doctor who would deny. that many a patient are cured mainly because of the faith they have in the efficacy of mixtures and pills given to them. It is well accepted that lack of faith and confidence or conviction in a patient that he would not recover. alone can reduce the chances of recovery.

Amongst ancient healers, considerable knowledge was gained by experience, and it is recorded that plants of medicinal value were in extensive use in different parts of the world. Opium, coca, quinine, sarsaparilla, tobacco, and many other similar herbs were prescribed for different maladies in ancient times.

Recorded medical history has its beginning in early Egyptian and Babylonian inscriptions and a great deal of information has been obtained from Egyptian mummies, that covers the period from 2000 to 500 B.C. Although there is no evidence of syphilis, but rheumatoid arthritis was common. Gout was also known, and so were probably gall stones, smallpox and rickets. By about 1500 B.C. it was realized that leprosy could be transmitted by contact, and leprosy patients, then called lepers, were cast out of society and forced into isolation.

Our most extensive early knowledge is from Jewish sources, the Bible and Talmud where references occur to

plague and hygiene. In hygiene great stress was laid upon cleanliness and prevention of disease by contacts. Meanwhile there had been independent advances in India and Ceylon (Sri Lanka). Sinhalese hospitals date from times even earlier than 400 B.C. Authenticated early written work from India can be traced to fifth century A.D. ; in it malaria is described and attributed to mosquitoes. The Indians had recognised some of the cause relationship of plague which was said to occur when rats fell from the rafters, jumped about and died. They also discovered inoculation against smallpox by variolation, were probably the first to use mosquito nets and also certainly the first to use anaesthetic prior to surgery. Indians described at least 760 species of medicinal plants and a wide range of surgical techniques with their appropriate instruments. Even though not recognised as such, these can be considered the scientific beginnings of medicine. There must have been careful observation, selection for relevance and successful application, the three essential ingredients of the methods of science. Ayurveda – meaning science of longevity indicated the promotional, preventive, curative and restorative aspects, though the practice of it was individual curative medicine only. Over 4 thousand years ago in India sanitation and housing were of a high order.

Gautama Budha propounded 4 truths—2500 years ago—that (i) there is disease and suffering in the world, (ii) that there is a cause, (iii) that there is a means of removing the cause, (iv) and that there is a path by which this can be accomplished. Hospital system had also developed in India during the reign of Rahula Sankirtyana (son of Budha).

Community sanitation perhaps did not develop as a public health exercise, but for aesthetic reasons. Human beings will avoid living close to their own excreta, will not tolerate dog faeces in their gardens, and were anxious to

remove horse faeces to dump in bushes. When excrement is not properly disposed many problems may arise. A range of parasites may enter the body through the mouth and cause illness, the most serious at the present time being typhoid and paratyphoid fevers. Modern civilisation still follows the easy route of pre-historic times of burying faeces deeply in the sub-soil.

In tropical and sub-tropical countries a number of parasites can cause serious concern. The two important in the Indian context would be hookworm and malarial parasites. Hookworm gains entry to human body through skin surface. Eggs that are passed out in faeces hatch into larvae dwelling in the soil. Human beings walking barefoot on contaminated ground have the larvae burrowed through the sole of foot to reach the blood stream and finally the intestine. Sanitation is the only control measure.

Of all parasitic diseases, malaria is not only the greatest killer, but also one of the most widespread diseases. There has been a long history of malaria. A severe form was rampant when Rome collapsed destroying many thousands of people. Malaria parasite is a very minute organism living within the red blood cell and has a separate development in certain mosquitoes of the genus anopheles. The female mosquitoes are infected by feeding on human blood and eventually their salivary glands come to contain a large number of these parasites. When these blood sucking insects bite, they inject their saliva into the wound and infect the individual. Usually the most effective control of malaria is to prevent mosquitoes from biting and to create mosquito free micro-environment by a variety of methods. The use of mosquito repellent that acts by giving off vapours to ward off mosquitoes, sleeping under mosquito nets and use of slow burning material like mosquito coil whose smoke keeps away

insects are some of the methods employed. Widespread control of mosquitoes involves use of spray of residual insecticides such as DDT, or attacking acquatic stages of development of mosquitoes either by use of larvicides as paris green or larvae eating fish. Even today malaria occurs or has occurred in all continents, mainly between the latitudes 60° North and 40° South. Malaria still causes more than a million deaths a year, most ot them in Tropical Africa. Although the disease has been eradicated in the recent past from Australia, Europe, U.S.A. and majority of the Carribian Islands the disease remains highly endemic and therefore a major public health problem in virtually all of Tropical Africa and in several countries in Asia, Central and South America, and our country. Throughout the world there are approximately 150 million clinical cases annually, although the number of people infected is much higher. It has been estimated that every year the disease causes the death of 1 million children under the age of 14 years in Tropical Africa alone (W.H.O. technical report No. 537, 1974). Malaria has been recognised as a major hindrance to economic progress in most of the developing countries. From time immemorial malaria has posed the greatest hurdle towards the path of human progress and prosperity in this great sub-continent. In the post–partition period it was estimated that the incidence of the disease was about 75 million cases annually with 0·8 million deaths, directly and an equal number indirectly. The country's annual economic loss was estimated at about Rs. 7500 million a year.

As a result of National Malaria Control and Eradication Programme, the case incidence declined to about 1 lakh in 1965 and the deaths were completely eliminated. After achieving remarkable success, the incidence of malaria started increasing again year after year and during 1975, 5.17 million cases have been recorded.

We have formulated a 'Modified Plan of Operation' where the objectives are "to prevent deaths due to malaria, to maintain industrial and green revolution and to retain achievements gained so far. To achieve the above goal a three-pronged attack on the problem of malaria is being made, namely : "Government's efforts, research and people's participation".

When we look upon the development of scientific medicine from renaissance on, it becomes at once clear that clinical medicine owes a great deal to fundamental physical and biological sciences. Most outstanding discoveries in the field of medicine have awaited an appropriate technology in basic sciences.

From the time of the development of microscope by van Leuwenhock in 1963, micro-organisms have been seen in water, and in fermenting liquids. It is from one of the pre-existing organisms that a French scientist, Louis Pasteur developed a revolutionary idea. He isolated and cultivated the yeast cells involved in fermentation and also discovered the germs which cause the milk to sour and butter to go rancid. Pasteur was the first one to show that diseases can be caused by microbes during his work on anthrax. By establishing what has come to be known Germ Theory of the disease, Pasteur not only put vaccination and inoculation upon a sure and expanding base, he also in 1878 realised the utter necessity of cleanliness in surgical operations.

Medical bacteriology has expanded greatly since the time of Pasteur. Our knowledge on the way in which bacterial invasions take place has led to development of appropriate measures to control bacterial infections. A study of the natural defence mechanism of the human body to ward off infections from outside has given rise to the

entire science of immunology. The human body manufactures small globulin particles called antibodies which can specifically fight bacteria and viruses rendering them innocuous. In many cases this capacity of the human body remains in existence for many years, after natural infection by the disease-causing organisms such as chickenpox, mumps, smallpox and measles. Artificially such an immunity is conferred on populations by inoculation and vaccination of suitable meterial. Smallpox was one of the mankind's most feared and devastating disease. It was responsible for death, blindness and disfigurement of countless millions throughout the world. In India, even as late as 1974, it was responsible for more than 1,88,000 cases. But today the ambitious programme to eliminate smallpox once for all from our planet appears to be within reach. This may be considered as a historic milestone in medicine. The success has been achieved by using several scientific innovations.

Edward Jenner discovered the world's first vaccine. He noticed a disease in cow which was called cowpox and people taking care of the cows did not get smallpox Dr. Jenner thought "may be if I infect people with cowpox virus, they will not catch smallpox"–and it was so. To deliver the potent vaccine to the periphery, one important technique has been used, *i.e.*, lyophilization of vaccine. In this process, the vaccine is prepared by rapid freezing and drying under high vacuum which makes the living biologic materials stable in tropical conditions. Since 1974, India is self-sufficient in the production of quality freeze dried smallpox vaccine.

The use of bifurcated needle has simplified the vaccination technique. Bifurcated needle was found to be highly effective in multiple puncture-vaccination. Not only did the new needle require less quantity of vaccine but it was also less traumatic. The recent knowledge of immunology was

responsible for introduction of one insertion technique and neo-natal vaccination.

Traditional campaigns of mass vaccination were aimed at indiscriminately vaccinating everyone regardless of their risk against smallpox. The programme was modified with emphasis on the detection of cases and their rapid containment. Containment vaccination is oriented to protect each and every person where smallpox is present, and then selectively immunizing those people considered to be at high risk for acquiring the disease. This change in strategy was the principal factor for the rapid interruption of smallpox transmission in many countries.

Eradication of smallpox is an example of the rational application of the already existing scientific knowledge in the field and among the masses.

Ever since the discovery of the circulation of blood, from capillaries to veins to or the heart, and thence to the arteries and to the capillaries again, by William Harvey, much has been learnt about the functioning of almost every part of the human body. The relationship between certain diseases and the abnormal numbers of blood cells is now well known and this knowledge has been augmented by biochemical tests upon a great variety of substances which are normally or abnormally present in the blood. A whole science of clinical biochemistry has come to exist. The development of instruments of increasing sophistication, to detect and measure the abnormal dynamics of the circulatory system, has led to the development of a sub-speciality of medicine known as cardiology. From the stethoscope, we have now electronic devices, capable of recording minute details of the activity of heart, and the abnormal cardiac action can be visualised immediately on the screen. Long before the electronics of the heart-beat recordings became known, a major advance in the application

of physics to medicine was the discovery of x-rays and radio-activities. The x-rays have been applied widely in diagnosis and treatment of diseases and presently the radio-active material is widely employed for treatment, diagnosis and as a tracer substance for understanding the normal and abnormal functioning of the human organisms. Pain and sepsis have been brought under control giving surgery almost unlimited scope in patching up ravages of disease. The sulpha drugs and antibiotics have given us tools to bring devastating diseases like tuberculosis, even leprosy under control.

The combined skills of microbiology and immunology have given us various vaccines which can protect our children from killing diseases like diphtheria and crippling ones like poliomyelitis. Many of the hazards of childhood and child birth can be conquered, so that more and more people can reach the scriptural age of three score years and ten.

The recent decades have witnessed the staggering advances and development of surgical management of so many hitherto incurable cardiac conditions—employing Heart Lung machines and even Heart Transplantation is now possible. Similar phenomenal advances have taken place in several other surgical fields as neuro-surgery and trans-plantation of organs. Kidney transplantation is now commonly practised.

Notwithstanding the great achievements of modern scientific medicine enumerated above, the majority of the world's rural population still do not have access to medical care. A quarter of the children in some of the communities die during their first year. Infant mortality in our country (1971 S R.S.) stands at 122 per 1000 live births. (Appendix II).

Communicable diseases, epidemic and endemic, are a day-to-day reality. The general picture in the world today, is one of an incredibly expensive health industry catering not

or the promotion of health but for unlimited application of technology for individual care and sickness. This distortion of health work is self perpetuating. Vast professional establishments concentrate on a few complicated problems with the result that professional education and training are geared towards the same purpose. Even in medical research the main thrust is towards the pursuit of disease-oriented problems. Even in less developed countries probably more than 90 per cent of research now going on, concerns problems seeking solutions that would benefit less than 10 per cent of their population. Medicine has too long concerned itself with individual sickness and the trends are that its primary concern should be the health care of the community. Health has been aptly defined by WHO as a state of complete physical, mental and social well-being and not merely absence of disease or infirmity. The enjoyment of the highest standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition.

Community health implies comprehensive health care for a defined population. The nature of community health needs, includes such problems as sanitary requirements, prevalent diseases, common injuries and the causes of death. Such comprehensive health care to the community can be delivered only through organization of health team in which every member of the team knows the purpose and the objectives to be achieved. Each member knows precisely what he or she is supposed to do towards the attainment of these objectives. The task of the team is to promote health of the community, to prevent disease, to treat the sick, when prevention has broken down and to rehabilitate the people after having been cured. Public health measures and developing medicine have reduced death rate and improved expectation

of life at birth. In India it was about 31 years at the time of independence and at present is about 52 years (Appendix I).

In the words of Director General of WHO, "longevity, however, has not brought the happiness that many assumed it would. Long life without improvement in the quality of life is one of the tragic sequels of technological development in many countries."

Medical science can give us absence of disease. It cannot give us health. Country's and communities' resources can provide all physical components, as better sanitation, efficient medical services, better housing, better towns, but it has been said, "Others can provide a house for you, but they can never make it a Home". Similarly health in ultimate analysis depends not on services but on self.

Health begins at home. It is only through community health action, that each man's home can be a true shelter against hazards of his environment. From this concept of health, health education has got enormous influence on the perspective of health of community.

We have so far dwelt only on physical health. What about mental and social health ? Mental health is recognised today as an essential and inseparable part of the total health. Poor mental health imposes at least the same handicaps in life as does physical health. Not only do emotional problems limit our capacity to live and enjoy life fully, they frequently also result in physical illness. The misuse of drugs today can be regarded as a problem of emotional health.

Our individual, community, or even national welfare depends upon understanding each other socially. Social stresses can cloud the life of millions of people. A minimum level of social understanding is essential for pleasant relationship with members of different religions, ethnic or social groups.

With increasing world population the success for world peace requires finding solutions for many problems that relate to emotional and social health of the nations. The human race is reproducing today at the fastest pace ever. It took from the beginning of man to around 1830 A.D. for the world population to reach a thousand million. Another 100 years were required to add the next 1000 million, and only 30 years between 1930-1960 for the third 1000 million. World population has now reached 4000 million. By the end of the century, we may well be adding a thousand million people every 5 years to consume, congest and pollute.

The implications of these figures are staggering for individuals, for families and for nations of the world.

Instead of improving the quality of life and reducing deprivation, economic growth is absorbed by population increases. Programme of population control is the only way – the only sane and humane method to problems posed by population growth.

While limitation on family size is important for both individual happiness and world welfare, the problems confronting man at the present time can be 'simplified' into opposite extremes. On the one hand, the majority are underfed and produce children faster than the environment can support their basic needs, while on the other, there is an overfed minority who are planning their family sizes. These social inequalities are a continued source of friction at international levels. Burnet has noted a tendency towards the development of making groups amongst intellectual elite of America, which could lead to "groups with special genetic capacity to excel in socially significant activities." This might have curious, perhaps disastrous, social results in an affluent and longly leisured civilization of the future.

Scientific world cannot afford to remain a mute spectator to these social trends. Anyone nation cannot prosper at the expense of other nations. The world has become so small today that misery of one nation is bound to affect the other. International co-operation is the only scientific way out of the present impasse.

Today man's challenge, above all others, is the use he makes of science for benign use for man's good or for malign use. As an illustration, nuclear energy which man's ingenuity has released can be used for his immense good to serve him or destroy him.

APPENDIX I

Expectation of Life at Birth by Sex from 1872–1981 in India

Period	*Expectation of life at Birth in Yearss*	
	Male	*Female*
1872–1881	23·7	25·6
1881–1891	24·6	25·5
1891–1901	23·6	24·0
1909–1911	22·6	23·3
1911–1921	19·4	20·9
1921–1931	26·9	26·6
1931–1941	32·1	31·4
1941–1951	32·4	31·7
1951–1961	41·9	40·6
1961–1971	47·1	45·6
1971–1976 (P)	50·7	49·3
1976–1981 (P)	53·2	51·8

Source : Sample Registration Bulletin Vol. VIII, No. 1-1974. Registrar General of India
(P)—Projections

APPENDIX II

Infant Mortality Rates for Registration Areas in India

Period	*Infant Mortality Rate*	
1911–1915	204	(5-year average)
1916–1920	219	do
1921–1925	174	do
1926–1930	178	do
1931–1935	174	do
1936–1940	161	do
1941–1945	161	do
1946–1950	134	do
1951–1961	146	(Actuarial Report)
1963	146	(Rural India)

	Rural	*Urban*	*Combined*
1968	137	N.A.	N.A.
1969	140	N.A.	N.A.
1970	133	86	125
1971	131	81	122

Science and The Scientific Temper

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1. Science as a Corporate Activity

Science as we know of it today was born in the West. For some three or four centuries, it has been pursued in Western countries as a vital human activity. Science came to India about a hundred years ago and in the last 25 years we have invested enormous sums of money for its development. It is, however, an implant from outside and if it is to thrive and bear fruit in our soil we must understand how it works. Today, I shall deal with some of the characteristics of science which appear not to have been appreciated in our country.

I shall begin by considering the popular notion of a scientist and his pursuit. It is that a scientist is an individual, intensely interested in Nature and with a keen desire to understand it. He studies natural phenomena assiduously. On the basis of these studies he devises laboratory experiments and makes careful precise measurements. He seeks systematic relationships which, if he finds, he explains by generalisations and theories. Predictions based upon these theories are sought to be verified by further experiments, which, if successful, lead to the recognition of new laws of Nature.

This picture of a scientist contains many of his essential characteristics but misses out one of the most important elements of any scientific activity. What is missed here is brought out clearly by the famous words of Newton where he said :

> "If I have seen farther than others it is
> because I stood on the shoulders of Giants."

This statement is often interpreted as revealing the innate modesty of this matchless scientist and quoted for that reason. The greater truth in it, however, is the realisation by Newton, who saw clearly even at that early stage, that corporate activity was essential for *building the Edifice of Science.*

In seeking his own vision of Nature the scientist already has the benefit of *all* that has been seen by his predecessors. Newton was acknowledging that a scientist builds on all the accumulated knowledge of all previous scientific activity.

How do scientists know what has gone before ? It is by evolving a culture of communication with each other. *For they know that if they do not communicate with each other, their discoveries will die and so will science eventually.*

When scientists were few, this communication was effected by writing to each other – telling each other of their experiments, their discoveries, their theories and of their doubts. While such personal communication still fortunately persists between investigators in the same or closely allied fields, the standard method of communication is by the publication of one's findings in so-called scientific journals. By this process of publication, any new idea or new experiment is "exposed" and becomes available to scientists all over the world. It will then be subjected to a critical examination by

large numbers of the scientific fraternity who form an invisible "college of peers." The first reactions of this group to any new discovery is invariably one of healthy scepticism or even of incredulity. They will not only repeat the experiments and check the calculations, but also go into the hundred implications that these results may have for workers in the same or related fields.

If the original work fails to stand up to this intense scrutiny and/or experimental tests, it will be dismissed by the scientific world and will die a quiet death. We see, therefore, that while scientific discoveries are made by individuals their acceptance and assimilation into the body of science rests on the scientific community.

To a man of science his jury today is a large body of well informed peers. It is to them, in a manner of speaking, that he submits his findings. Because of the inevitable public assessment and debate that must take place, silently or otherwise, a scientist must necessarily impose upon himself a rigorous discipline. This unrelenting jury of peers exerts such pressures that he cannot but be impartial as an experimenter or observer. For he knows—how unforgiving this scientific jury can be if he is found to be wrong. It can, without the least ceremony, condemn his experiment or worse still, ignore it and drop him by the wayside.

It is in this sense that science is public and corporate – even democratic but where only the views of well informed peers really count. In this way new ideas spread rapidly, discoveries breed other discoveries, and what is more important erroneous observations and illogical deductions are soon corrected. It is by this process that science maintains standards, pools information and encourages cross fertilisation in the realm of ideas.

The existence of this invisible college of peers is a prerequisite for the healthy growth of science in any society. No one sets up this college, no one elects them. It is in the nature of healthy scientific activity that such an invisible group automatically forms itself and assumes the role of watch-dog of science and its quality. Its acceptance or rejection of the scientific work of an individual becomes the criterion determining his standing in the community.

An effective jury of the above kind can be found in any country where science thrives. In India, on the other hand, such evaluation by fellow scientists is signally absent. As a consequence, the salary, position and influence of any scientist is determined by hierarchical and other considerations unrelated to his scientific standing.

On a recent visit abroad I had occasion to visit a number of scientific centres in Europe and the United States of America. At each of these centres I could feel an intellectual ferment. The young men and women who worked there were excited about the latest things that were happening in science all over the world. The arrival of any reputed scientific journal was an occasion and the work reported therein was discussed at breakfast counters. dinner tables and beer parlours.

Such excitement is sadly absent in the Indian scene. The arrival of journals is scarcely noticed. We have an enormous number of scientific laboratories and universities, but in all of them the hierarchy prevails. There is an atmosphere of feudal secrecy of the kind associated with medieval craftsmanship. Communication—the very basis of modern science does not exist even between groups in the same institution. The obvious characteristics of science that

I have just described are conspicuous by their absence. No wonder we have no standards in science.

This dismal situation is perhaps the price one has to pay for the intensive unplanned attempt to establish science in our country. I don't know but I feel there is hope—if for no other reason than that the very many talented young men and women who have been inducted into our laboratories cannot all be silent, or be silenced. Surely it is from them that a peer group will emerge to judge and regulate the quality of science. Unless this happens Indian Science will never stand on its own feet.

2. The Scientific Temper—Nehru's dream

I am not certain whether Nehru coined the expression "Scientific Temper" or not. He had a great knock of choosing apt words to suit special purposes. In any case there is no doubt that it was he who championed it giving it a new interpretation and a new meaning.

The method by which science progresses is by experiment, reason and logic. Nehru wanted this rationalism of science to spread throughout the length and breadth of our land. To him this appeared to be the only method of alleviating the suffering of our countrymen and of raising them from the abject state they were in. To Nehru a scientific temper was the sword which by its rationalism could fight the darkest forces of superstition. It was also the shield which could protect us from prejudice, ignorance and obscurantism which have kept us enslaved and degraded all these years. Only by having the scientific temper simmering in everyone of us could India launch new adventures into the Unknown.

This was the vision of Nehru who did all he could to propagate and support science in India.

A quarter century has passed since these ideas were voiced. During this time we have spent enormous sums of money, established scores of laboratories, and produced hundreds of thousands of so-called scientists from our universities. It has been proudly claimed that our nation has the fourth highest number of scientists in the world. Bat the dream of the great Indian is as naught. Obscurantism and unreason reign supreme. The scientific temper is by no means a way of life either amongst the "scientists", the students or the people at large.

The first reaction of people committed to the propagation of science in India is often to be angry, to condemn the state of affairs, to attack individuals personally or the scientific community as a whole. This is not of much use. The better, saner and clearly the more scientific method is to analyse the causes of this unbelievable situation. Once we know them we could perhaps arrive at possible or even feasible solutions. From this point of view let us look in turn at the attitudes of our scientists, students and the people at large.

3. The Isolation of Indian Scientists

Let us first examine objectively the scientific community which, in spite of its weaknesses, does manage to produce some good research. Most of this research although done in India is published abroad.

When a scientific paper is sent to a journal for publication it is studied by competent scientists who are called referees. They assess and criticise it. The author then

makes necessary modifications and resubmits the paper. If it is found satisfactory the paper is published by the journal. If the paper is good, it is accepted by the scientific community. If it has something new or outstanding the author gets name and fame. Since the journals, the referees and the scientific jury are generally not Indian, all this happens abroad.

On the face of it there seems nothing wrong in this procedure since, after all, science is international. In fact a scientist is likely to get a better assessment of his work from an international referee than from an Indian one. But there are very many serious repercussions and these have not been fully appreciated in India. Sending publications abroad weakens all the attempts being made to build up a peer group – that I talked about earlier–inside India, the group that will finally maintain standards and regulate the quality of science in the country.

Since the peer group operative now are based abroad, our scientific activity will necessarily follow fashions set in the West. If this situation is not changed in the future we shall always be followers, never be leaders.

But perhaps the most pernicious effect of our dependence on peer groups abroad is that our science gets divorced from our national activity. To many a scientist this is a good way out as it permits him to separate his day-to-day attitudes from his scientific activity and lead a happy dichotomous life. His scientific activity is actually for another far away world. For life here he can continue to nurture the superstitious and obscurantist views which match so well with the reactionary society he lives in.

All this has to be broken. But at best it is likely to be a very slow process. No matter how long it takes, it is only

when scientific activity is integrated into the Indian scene can the Scientific Temper become a way of life with us.

4. Students and University Education

Let us next see what we do to our children and our youth in our schools and colleges. Do we teach them the scientific method with its logic, its rationalism and its insistence on the experimental method ? We can categorically say that we do not.

Many of the young who come into our schools or universities are bright and intelligent. Unfortunately, the family background and the society they live in provide poor soil for the growth of the scientific attitude. It is only in the school or the university that one could hope to encourage a scientific outlook.

But instead what we actually do is to clutter up their young minds and confuse them. We teach science to our young, not as a process or a method, but as a collection of formulations – whose logic they are not encouraged to understand but which they are required to learn by rote. To many of them mathematics is a form of magic which provides solutions to problems. Science to most of them is some form of mumbo-jumbo to be learnt "by heart" to be regurgitated at an examination.

Any "educated" young man has been confused both by his university and by society. When he is required to calculate the strength of a beam, he uses formula X on page Y in the prescribed text book on Properties of Matter. When he wants rain, he recites the formula A in canto B in the Varuna Sastra. It is indeed a pity that our university education has not taught him to

tell rationalism from ritualism. Our schools and universities must not teach science as a collection of indigestible data as they do now—data can always be acquired. Science must be taught as a process of thought—a method always appealing to experiment, followed by logical deduction.

"The young mind is a torch to be lighted and not a vessel to be filled", says a Ukranian proverb. To achieve this the teachers must first be taught. The examination system must be scrapped. Public debates must be held as to how to modify the educational system, so that our young who come out of schools or universities are not repositories of useless data and formulations but are thinking minds–ready to apply the scientific method. Most of the problems associated with our country and our people cannot be solved by readymade nostrums or formulations. Only fresh minds which can give them deep thought can find solutions. Mr. Vice-Chancellor, I suggest that this should be your most important task.

5. The People and Science

We finally come to the people of India, the stuff of our nation. They have been told time and again that science is *the* solution, the Cure-All of all illnesses. And they have been waiting for this miracle to happen. To them this miracle is no different from the miracles of materialisation about which we have heard so much recently – with the difference that some of them have "seen" the latter happen! Against this background it is understandable that the inculcation of the Scientific Temper will be very difficult indeed.

But one thing is certain that it cannot be propagated amongst our people unless we explode the Myth of Science as the "Great *External* Solver" of all problems.

Every man must realise that the method of science is not external to him. It is inside him. If he has a difficulty or a problem he could set a process into motion, which may finally solve it. As to how one propagates this concept as a universal principle I have no ready made solution. But I feel the Mahatma came closest when he laid down the basic methods of propagating self-reliance which is really the essence of the scientific method.

''ಧರ್ಮಸ್ಯ ಫಲಮಿಚ್ಛನ್ತಿ ಧರ್ಮಂ ನೇಚ್ಛನ್ತಿಮಾನವಾಃ''
(ಮನುಷ್ಯರು ಧರ್ಮದ ಫಲವನ್ನು ಅಪೇಕ್ಷಿಸುತ್ತಾರೆ. ಆದರೆ ಧರ್ಮವನ್ನು ಆಚರಿಸಲು ಬಯಸುವುದಿಲ್ಲ.)

—ವಿದುರ ಧೃತರಾಷ್ಟ್ರನಿಗೆ ಹೇಳಿದ್ದು

We must conclude that the attention and respect accorded to science is directed wholly to its results, and its spirit is the most unpopular thing in the modern world. Yet it could very reasonably be claimed that it is in its spirit that the chief value of science resides.

J. W. N. Sullivan—'*Limitations of Science*'

Those that get a living by calculation of the stars by such art and other lying tricks are to be avoided.

Buddha– '*Vinayapitaka*'

Star-gazing and astrology, forecasting lucky or unfortunate events by signs, prognosticating good or evil, all these are things forbidden.

'*The Gospel of Buddha*'

Fearlessness is the first prerequisite of spirituality. A coward can never have any morals.

— *Mahatma Gandhi*

Extracts from The Complete Works of Swami Vivekananda

I believe in reason and follow reason having seen enough of the evils of authority, for I was born in a country where they have gone to the extreme of authority.

(Vol. 2, Page 336)

Superstition is a great enemy of man, bigotry is worse.

(Vol. 1, Page 15)

Down with all superstitions ! *(Vol. 1, Page 502)*

Be pure, give up all superstition and see the wonderful harmony of nature. Superstition gets the better of religion. *(Vol. 2, Page 483)*

But woe unto the man and woe unto the nation that forgets the real, internal, spiritual essentials of religion and mechanically clutches with death-like grasp at all external forms and never lets them go.

(Vol. 3, Page 68)

Let stars come, what harm is there ? If a star disturbs my life, it would not be worth a cent. You will find that astrology and all these mystical things are generally signs of a weak mind ; therefore as soon as they are becoming prominent in our minds, we should see a physician, take good food and rest.

(Vol. 8, Page 184)